PB-222 304

ANNOTATED BIBLIOGRAPHY OF LAKE ONTARIO LIMNOLOGICAL AND RELATED STUDIES. VOLUME III - PHYSICAL

John Baldwin, et al

State University College

Prepared for:

Environmental Protection Agency

March 1973

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PB 222 304

EPA-R3-73-028c
MARCH 1973
W73-12755

Ecological Research Series

ANNOTATED BIBLIOGRAPHY OF LAKE ONTARIO LIMNOLOGICAL AND RELATED STUDIES

Vol. III - Physical

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SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

1. Report No.

2.

3. Accession No. W73-12755

4. Title Annotated Bibliography of Lake Ontario Limnological and Related Studies - Vol. 111 - Physical, [illegible]

5. Report Date

6.

8. Performing Organization Report No.

7. Author(s)

Baldwin, J~~ohn~~ and R~~obert~~ A. Sweeney

10. Project No. EPA-[illegible]

9. Organization

Great Lakes Laboratory
State University College at Buffalo
~~5 Porter Avenue~~
~~Buff~~alo, New York ~~14201~~

11. Contract/Grant No. 16120 HVR

13. Type of Report and Period Covered Oct~~ober 1971 - Jan. 1972~~

12. Sponsoring Organization ~~Environmental Protection Agency~~

15. Supplementary Notes (Ecological Research Series)

Environmental Protection Agency, report ~~number~~, EPA-R3-73-028c, March 1973. 203 p. 1 fig

16. Abstract

Four hundred thirty-nine (439) papers concerning physical aspects of Lake Ontario and influent tributaries were reviewed and abstracted. Each paper was cross-indexed by author, geographic area of lake and/or tributary in which study was performed, parameters, techniques and instrumentation. In addition, a list of addresses for the authors and agencies was included along with other possibly pertinent references which the authors were not able to secure and review within the time limitations of the grant. (See also W73-12753 and W73-12754)
(EPA abstract)

17a. Descriptors

*Lake Ontario, Great Lakes, Limnology, *Instrumentation, *Bibliographies, *Physical properties, Abstracts

17b. Identifiers

73-028C

Copy available from GPO Sup Doc as EP1.23/[illegible], $2.60; microfiche from NTIS as PB [illegible], ~~$0.95~~ 1.45

17c. COWRR Field & Group 02H 10C

18. Availability

19. Security Class. (Report)

20. Security Class. (Page)

21. No. of Pages

22. Price

Send To:

WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D. C. 20240

Abstractor

Institution

EPA-R3-73-028c
March 1973

ANNOTATED BIBLIOGRAPHY OF LAKE ONTARIO LIMNOLOGICAL AND RELATED STUDIES

Vol. III - PHYSICAL

By

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Project 16120 HVR

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Prepared for

OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price $2.60 domestic postpaid or $2.25 GPO Bookstore

EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial production constitute endorsement or recommentation for use.

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I. INTRODUCTION

The purpose of this study, which was sponsored under grant # 16120 HVR from the U. S. Environmental Protection Agency, was to provide a reference that would be of aid to those individuals and/or agencies, planning or initiating limnological research on Lake Ontario and/or its tributaries, particularly those activities which are part of the International Field Year on the Great Lakes (1972-74). The task was divided on the basis of disciplines into three (3) sections - chemical, biological and physical. This paper is the final report from the latter.

The holdings of libraries in both the United States and Canada were surveyed. Each pertinent reference was abstracted and examined with respect to the parameters measured, techniques employed and the location(s) in which the study was conducted. In addition, the last known address of the agency or senior author was noted for inclusion of locating the author if further communication is desired.

Unless otherwise noted, the papers cited in the annotated bibliography are located in Buffalo.

Due to limitations in time, we were unable to secure copies of a few references that may contain information relative to Lake Ontario. These have been included in this paper.

Comments concerning this work are welcome and appreciated.

II. SUBJECT INDEX

The number following each, refers to the number of the paper listed in Section II. Lake Ontario was divided into eighteen (18) regions, which are shown in Figure 1. The number nineteen (19) refers to lake-wide studies; while twenty (20) concerns tributaries to the lake. For the identification of the specific stream or river in question, see the abstract.

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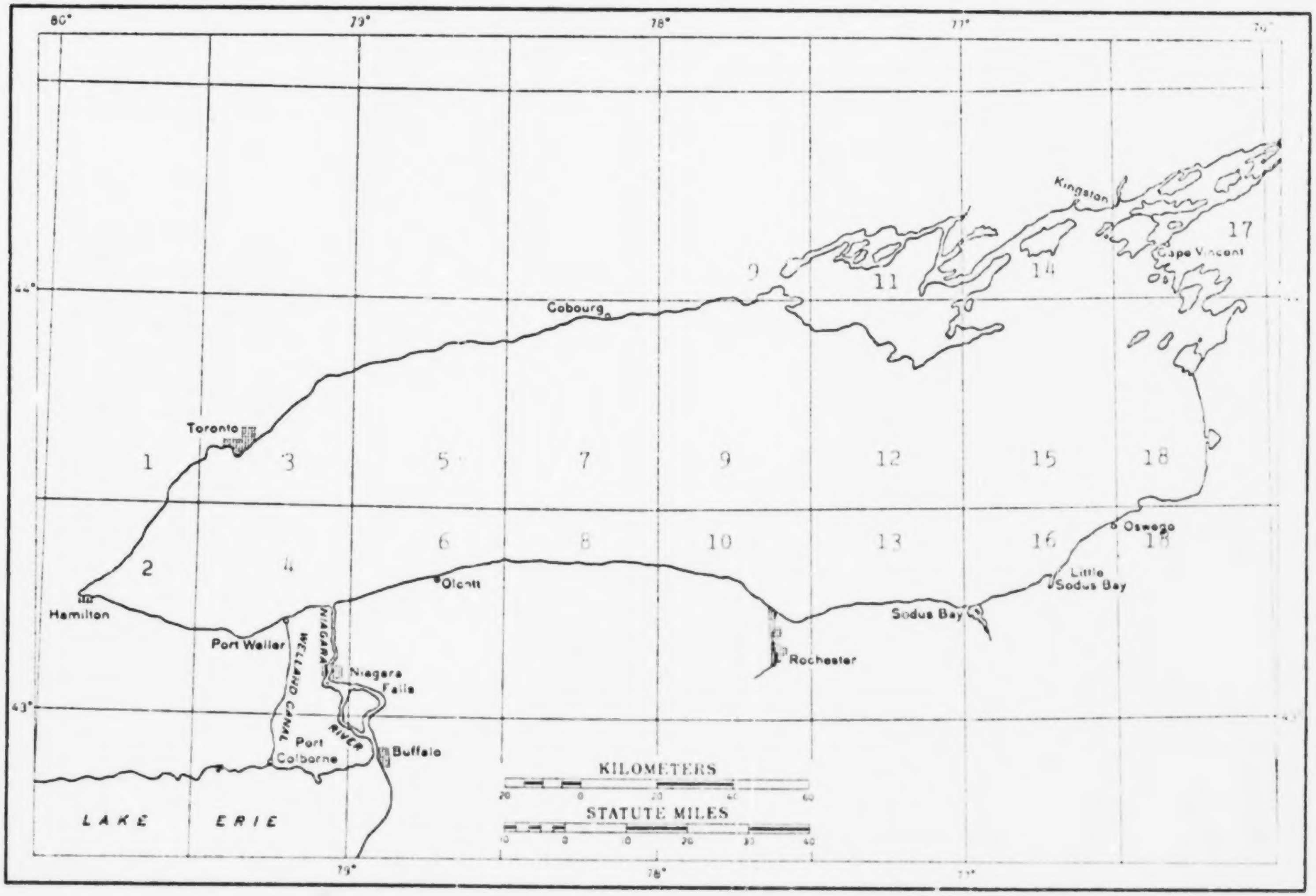
FIGURE 1 - MAP OF LAKE ONTARIO


80°
79°
78°
77°
76°
44°
43°
Toronto
Hamilton
Cobourg
Kingston
Cape Vincent
Oswego
Little Sodus Bay
Sodus Bay
Rochester
Olcott
Port Weller
WELLAND CANAL
NIAGARA RIVER
Niagara Falls
Port Colborne
Buffalo
LAKE ERIE
KILOMETERS
20 0 20 40 60
STATUTE MILES
10 0 10 20 30 40
1
2
3
4
5
6
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9
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III. ABSTRACTS

The location of those papers not found in Buffalo and available through the Great Lakes Lab are given in parenthesis at the end of the abstract.

1. Acres, H. G. 1970. Effects of thermal inputs to Lake Ontario, 1968-2000. Niagara Falls, Ontario. 81 p.

   Annual evaporation from the surface of Lake Ontario, resulting from man-made heat input, is expected to increase from 0.047 inches in 1968 to 0.14 inches in 1980 and 0.64 inches in 2000. The total increased evaporation from the surface of the Great Lakes over the natural state is estimated to be 0.1600 cfs by the year 2000. (Canada Centre for Inland Waters).

2. Adams, C. C. 1927. General description of Oneida Lake. Roosevelt Wild Life Annuals. 1(3 and 4):247-248.

   A description of the dimensional and physical characteristics of Oneida Lake with reference to location, dimention, depth, volume, waves, sediments, geological formations, glacial and post glacial deposits and drainage area.

3. Allen, W. T. R. 1964. Break-up and freeze-up dates in Canada Canadian Dept. Transport, Meteorological Branch. Cir. 4116, Ice 17. 301 p.

   As the result of a survey of meteorological stations made in 1956 to obtain historical records of the dates of break-up and freeze-up of rivers and lakes in CAnada; and the establishment of a continuing program at the stations to report these phenomena; the Meteorological Branch published, in 1959, Circular 3156, ICE-2, "Break-up and Freeze-up Dates of Rivers and Lakes in Canada." This circular contained listings of break-up and freeze-up dates for 87 rivers and 113 lakes, bays and harbours, up to break-up 1958.

   Five additional years of records are now available for the meteorological stations which have been engaged in observing the break-up and freeze-up of bodies of water in their vicinity. In addition, historical records, some quite lengthy, have been obtained for a number of other locations. This present circular lists all information acquired since the publication of Circular 3156, up to freeze-up 1963. (Univ. Toronto-Great Lakes Inst.).

Anderson, D. V. - See: J. P. Bruce, No. 43.

Anderson, D. V. - See: R. L. Drake, No. 162.

Anderson, D. V. - See: D. H. Matheson, No. 262.

Anderson, D. V. - See: G. K. Rodgers, No. 328, 329.

Anderson, D. V. - See: R. N. Simpson, No. 348, 349.

4. Anderson, D. V. 1959. The effect of a water temperature discontinuity on wind water interaction. Ontario Dept. Lands and Forests Research Division. Physics Research Note No. 3. 2 p., 1 Figure.

The passage of air over a body of water is a more complicated and far-reaching phenomenon than apparent to casual observation. As the strength of wind increases from zero and waves are generated in increasing size, several phenomena occur. For one, the vertical profile of the wind over the water is modified and energy is transferred to the water which is set in motion bodily, i.e. in addition to the surface disturbance of the water, a surface layer is associatively induced into motion by the wind. Because of the compounded difficulties of making correlative and simultaneous measurements on the air above and the water below, the mechanics of the interaction are not at all thoroughly understood. However, much work is being devoted to the problem in oceanographic research, and it is hoped to do likewise on the Lakes.

One facet of the matter lies in the difference encountered in the contrasting situation: air at a given temperature passing over water that is colder than the air; and over water that is warmer.

The first is termed a stable condition because the surface layer of air cooled by contact with the colder water, and therefore, heavier than the air above, tends to stay near the surface. It is well known that this cool layer acts as a lubricant on the general body of wind so that the air above is less affected by contact with the water and, correspondingly, the cool layer in contact with the roughened surface of the lake is slowed down. Therefore, the velocity will vary in the simplest case from close to zero very near the surface to the unimpeded maximum several hundred feet above the water.

The stronger the wind, the thinner the layer, for turbulence in the movement of the air increased by effects of waves will break down the layer and mix the cooler air with the warmer above, thereby permitting an increasing speed of wind and turbulence at the water surface and allowing a greater drag on the air above. In consequence of all this, winds of moderate speed with a given air temperature should produce smaller waves on water that is colder, than on water that is warmer than the air, although the evidence on this is not conclusive (Darbyshire and Darbyshire, 1950). (Univ. Toronto, Zeology Library).

5. Anderson, D. V. 1960. Canadian Great Lakes Research Program. The Conservationist. August-September. pp. 2-5.

An article on the Canadian Great Lakes Research Program initiated by the Ontario Department of Lands and Forests. Parameters for the years 1959 and 1960 include:

Temperature distribution
Ice observations
Echo Sounder bottom sediment survey

Water in the Toronto region of the lake has an average summer surface temperature of 65°F, while the more southerly areas were somewhat warmer (70°F average).

6. Anderson, D. V. 1961. A preliminary study of the energy budget of Lake Ontario. Journal Fish. Research Board Canada. 18(4): 617-636.

Recent bathythermographic surveys carried out on the research vessel Port Dauphine have provided estimates of the heat content of Lake Ontario and permitted a preliminary study of its energy budget. The imbalance between the absorbed sbort wavelength sun and sky radiation, and the losses due to evaporation, sensible heat conduction and net long wavelength back radiation result in heating of lake water from March to August and cooling from September to October to February. The peak heat content lags the peak surface temperature by about one month. The amount of energy advected into the lake is relatively small compared with other terms in the energy budget. Thus, energy budget calculations do not depend upon the accuracy with which the water budget is known. The principal difficulty in applying present techniques for determination of an energy budget is lack of meteorological data over the lake surfaces.

7. Anderson, D. V. 1964. Geophysical research on the Great Lakes. Ontario Dept. Lands and Forests. Research Report No. 55. 39 p.

A summary of geophysical research on the Great Lakes, the major research agencies, problems in physical limnology, and a discussion of instrumental techniques and methods. Also included are the various research fields and projects undertaken, and a proposal for organization of the geophysical research.

8. Anderson, D. V. 1967a. Diurnal motions of the thermocline of Lake Ontario caused by meteorological and tidal factors. Ontario Dept. Lands and Forests. Research Rept. No. 17. 15 p.

Average water temperatures at the summer level of the thermocline at Toronto reveal correlation with the four angles of both sun and moon. Their forms are diurnal and it is suggested that the solar correlation has superimposed upon a gravitational tidal component a diurnal meteorological component due to the wind.

9. Anderson, D. V. 1967b. A prolegomenon to the study of Lake Ontario. Ontario Dept. Lands and Forests, Research Branch. Report No. 81. 90 p.

This report is the last one of a series describing limnological investigations started by Dr. Anderson while he was with the Department of Lands and Forests.

This report presents data collected on surveys of Lake Ontario from 1955, 1958 and 1959. They are summarized in charts which will be allowed to speak mainly for themselves pending comparison with recent data. Four anomalies in temperature structure are commented upon and taken as illustrations to show that a physical research program oriented toward administrative action would be based, for the present, upon statistical models. Detailed explanations of motions will not be easily achieved and may not be necessary in many practical cases.

10. Anderson, D. V. (Ed.). 1969. The Great Lakes as an environment. Great Lakes Institute, Univ. Toronto. Report PR 39. 189 p. + appendices.

Tabulated data for the surface water of Lake Ontario are presented on: conductivity, dissolved solids and pH. A climatological summary of the Great Lakes Basin is included which summaries the data obtained from 110 Canadian and 160 U. S. weather stations located in the Great Lakes Basin.

Other sections included weather and temperature and currents in the Great Lakes. (Canada Centre for Inland Waters).

11. Anderson, D. V., J. P. Bruce, U. Sporns and G. K. Rodgers. 1961. Winter research on Lake Ontario. Great Lakes Research Division. Publication No. 7. pp. 185-198.

The relationship of meteorological and climatological factors and water processes are discussed. Water temperatures, meteorological factors, ice observations and storms are discussed.

12. Anderson, D. V. and Y. T. Lanbert. 1959. A synoptic survey of Lake Ontario in a Canso flying boat. Ontario Dept. Lands and Forests, Research Division. Note No. 2. pp. 1-2.

The advantage to this type of survey is that little variation takes place in climatology (winds, temp., etc.) during the very brief sampling period. The only disadvantage was the necessity for calm lake conditions for landing. (Univ. Toronto, Zoology Library).

13. Anderson, D. V. and D. H. Matheson. 1967. Hamilton Bay - The model of a natural waste treatment reactor Ontario Dept. Lands and Forests, Research Rept. No. 73. 15 p.

Hamilton Bay covers 11.3 square miles and communicates with Lake Ontario through a short shipping channel. All wastes from the city are discharged into the Bay where, in water averaging 20 feet of depth, they are subject to active and effective decomposition. Analysis of the Bay water and Lake water nearby have been made over 20 years, and during this period the Bay has been able to cope with the cities wastes. Increased pollution and reduced detention times now make problemmatical the stability of the bay as a sewage reactor. Of course, the reactions are much too complicated yet to be discussed even qualitatively, and therefore, it is not possible to defend increased demands on the Bay. In any case, secondary treatment facilities are now being built.

14. Anderson, D. V. and G. K. Rodgers. 1959. The delta of the Niagara River. Ontario Dept. Lands and Forests. Physics Research Note No. 5. 4 p., 7 Figures.

Most of the sands and all of the gravels are deposited within six miles of the mouth of the Niagara River. This indicates that the momentum of the River along the bottom is dissipated within the lake in approximately the same distance, or of the order of 10 miles. Thereafter, the movement of Niagara River water, while it will remain more or less en bloc for a much greater distance, must be controlled by Lake forces. The movement of warmer river water across the surface of relatively colder Ontario water is another matter upon which coarse bottom sediments shed little light since they settle out rapidly. Assessment of the distribution of silts should be diagnostic of such surface flow.

The orientation of the mouth directs the river water to the north-west and the greatest depths of material are deposited as shown by the contour lines in Figure 3 in a fan directed to the north-west. But the isodiametral lines of Figure 6 show that particles of a given size are moved further to the north-east than to the north-west. Superimposed upon the current of the river there must be a current which on the average is flowing easterly, and so causes earlier sedimentation. Now current and other measurements will be necessary to settle the matter, but in addition to wind-driven currents another type of flow may be partially responsible. It was found in the course of other work in 1958 that the flow of warm river water into the Lake may induce a coutour flow of colder bottom water from the Lake toward the shore, a flow which could account partially for the observed effect as indicated schematically in Figure 7.

Appeal to Figure 1 shows that the maximum velocity indicated by fine sand 0.001 inches in diameter (0.02 mm) is 0.004 mph (0.15 cm/sec., 0.005 ft/sec.). The depths at the -3.0 contour (Fig. 5)are about 200 feet and the very slight magnitudes of bottom currents indicated there, agree with those obtained by dynamic height calculations in the west basin. At the river's mouth, Station 40-11, the maximum particle size of 0.4 inches (10 mm) and calculated river flow velocity of 2.5 mph are in substantial agreement. The flow is approximately 190,000 cfs, and the dimensions of the river mouth are: width 1,300 ft., maximum depth 63 ft. (Univ. Toronto, Zoology Library).

15. Anderson, D. V. and R. B. Simpson. 1967. The surface tides of Lake Ontario. Ontario Department of Lands and Forests. Research Report No. 76. 42 p.

Monthly averages of surface levels at successive hours, reveal the lunar and solar tides of Lake Ontario. The relative amplitudes and phases in the eastern, central and western basins are in accord with theory. It is suggested that intensive tidal studies will help unravel puzzles in circulation and that they may be useful in constructing correlations with seasonal meteorological changes.

Anderson, S. R. - See: M. K. Thomas, No. 386.

16. Andrews, R. H. G. and S. A. Black. 1968. Diffusion of Lakeview WPCP effluent in Lake Ontario. Abstract of paper presented at the 11th Conference Great Lakes Research, Univ. of Wisconsin, Milwaukee. pp. 28-29.

As part of a general county survey involving the enlargement of the Lakeview Water Pollution Control Plant from 5 to 12 mgd. The project was undertaken to estimate the present and future influence of this waste effluent upon the water quality at the New Toronto and Toronto Township Waterworks intakes in Lake Ontario. Current velocity and direction was determined to be largely a result of wind conditions. Depending upon wind conditions at a given sample time, varying concontrations of Lakeview WPCP effluent could conceivably reach the water intakes of these areas, however, not in dangerous concentrations.

17. Archibald, D. C., M. N. Monsinger and T. B. Kilpatrick. 1959. Aerial ice observing and reconnaissance program in the St. Lawrence River, the Gulf of the St. Lawrence and the Strait of Belle Isle, 1958. Department of Transport, Meteorological Branch, Canada. Circular 3273. 19 p.

This is the second technical report in the series concerning ice conditions observed by aerial ice reconnaissance conducted by the Meteorological Branch, Department of Transport. This survey was carried out in cooperation with the Marine Branch, Department of Transport and the Geographical Branch, Department of Mines and Technical Surveys.

This technical report describes observed ice conditions with regard to ice coverage, age, topography, puddling, snow cover, ice of land origin and water features over the area of the St. Lawrence River, the Gulf of St. Lawrence and the Strait of Belle Isle during the period January to June, 1958, inclusive. (Univ. of Toronto, Zoology Library).

18. Archibald, D. C., M. N. Monsinger and T. B. Kilpatrick. 1960. Aerial sea ice observing and reconnassance - St. Lawrence River, the Gulf of the St. Lawrence and coastal waters of Newfoundland, 1959. Department of Transport, Meteorological Branch, Canada. Circular 3417. 99 p.

This is the fifth technical report in the series concerning ice conditions observed by aerial ice reconnaissance under direction of the Basic Weather Division, Meteorological Branch, Department of Transport.

This technical report describes observed ice conditions with regard to ice coverage, age, topography, puddling, snow cover, ice of land origin and water features over the area of the St. Lawrence River, the Gulf of St. Lawrence and the coastal waters of Newfoundland during the period from December 21, 1958 to June 24, 1959. (Univ. of Toronto, Zoology Library).

19. Archibald, D. C., M. N. Monsinger and T. B. Kilpatrick. 1961a. Aerial sea ice observing and reconnaissance St. Lawrence River, the Gulf of the St. Lawrence and coastal waters of Newfoundland, 1960. Department of Transport, Meteorological Branch, Canada. Circular 3465. 101 p.

This is the seventh technical report in the series concerning ice conditions observed by aerial ice reconnaissance conducted by the Basic Weather Division, Meteorological Branch, Department of Transport.

This is the third annual technical report covering observed ice conditions in the St. Lawrence River, the Gulf of St. Lawrence and coastal waters of Newfoundland.

This technical report describes observed ice conditions with regard to ice coverage, age, topography, puddling, snow cover, ice of land origin and water features over the described area during the period December 19, 1959 to June 28, 1960. (Univ. of Toronto, Zoology Library).

0. Archibald, D. C., M. N. Monsinger and T. B. Kilpatrick. 1961b. Aerial ice observing and reconnaissance - the Great Lakes, 1961. Department of Transport, Meteorological Branch, Canada. Circular 3530. 55 p.

This is the ninth technical report in the series concerning the ice conditions observed by aerial ice reconnaissance conducted by the Meteorological Branch, Department of Transport.

This technical report describes observed ice conditions with regard to ice coverage, age, topography, puddling, snow cover and water features over the area of Lake Superior, the North Channel, Georgian Bay, Lake Huron, Lake Erie, Lake Ontario and adjacent waterways, during the period January to April, 1961, inclusive.

This is the second technical report covering observed ice conditions in the Great Lakes. (Univ. of Toronto, Zoology Library).

21. Archibald, D. C., M. N. Monsinger and T. B. Kilpatrick. 1962a. Aerial sea ice observing and reconnaissance St. Lawrence River, the Gulf of the St. Lawrence and coastal waters of Newfoundland, 1961. Department of Transport, Meteorological Branch, Canada. Circular 3591. 157 p.

This is the twelfth technical report in the series concerning ice conditions observed by aerial ice reconaissance conducted by the Basic Weather Division, Meteorological Branch, Department of Transport.

This is the fourth annual technical report covering observed ice conditions in the St. Lawrence River, the Gulf of St. Lawrence and coastal waters of Newfoundland.

This technical report describes observed ice conditions with regard to ice coverage, age, topography, puddling, snow cover, ice of land origin and water features over the described area during the period from December 18, 1960, to June 27, 1961. (Univ. of Toronto, Zoology Library).

22. Archibald, D. C., M. N. Monsinger, T. B. Kilpatrick. 1962b. Aerial ice observing and reconnaissance - the Great Lakes, 1962. Department of Transport, Meteorological Branch, Canada. Circular 3772, Tec. 440. 55 p.

This is the sixteenth technical report in the series concerning the ice conditions observed by aerial ice reconnaissance conducted by the Meteorological Branch, Department of Transport.

This technical report describes observed ice conditions with regard to ice coverage, age topography, puddling, snow cover and water features over the area of Lake Superior, the North Channel, Georgian Bay, Lake Huron, Lake Erie, Lake Ontario and adjacent waterways, during the period December, 1961 to May, 1962, inclusive. (Univ. of Toronto - Great Lakes Institute).

Armstrong, J. L. - See: S. J. G. Bird, No. 30.

23. Ayers, J. C. 1962. Great Lakes water, their circulation and physical and chemical characteristics. American Association Advancement Science. Publication 71: 71-89.

The circulation of water in the Great Lakes involves surface and subsurface currents, with a seasonal cycle of verticle circulation superimposed. Current patterns are determined by wind, flowthrough of drainage water, rotation of the earth and local influences. Surface currents lag behind the causative wind by periods ranging from two hours in shallow water to a day in deep basins. Current patterns in deep basins apparently involve energy increments from the winds of the preceeding 10-12 days, with the increments increasing exponentially in effectiveness with increasing time prior to the observation day.

Primary physical characteristics of the lake waters are their "soft water" nature; their seasonal cycles of turnover, lake levels and precipitation; and their short period seiches. The lake exhibit a modified seasonal turnover cycle, wind mixing establishes turnover at the end of the fall cooling period and maintains it throughout the winter until the spring warming period is established. Cycles of the lake level occur annually the levels are low in midsummer. Superimposed on the annual cycles are multiyear cycles of level.

24. Bakewell, R. 1857. Observations on the falls of Niagara, with reference to the changes which have taken place and are in progress. American Journal Science. Ser. 2, 23: 85-95.

The Niagara Falls and their related erosion rates are responsible for the formation of the Niagara Gorge. The harder upper limestone formations are undermined by the erosion of softer shales and sandstones near the base of the falls. This causes collapse and subsequent erosion of the material under the falls. This is thought to be the mechanism for the gradual formation of the Niagara Gorge.

Baldwin, A. L. - See: R. C. Bubeck, No. 47.

25. Barrientos, C. S. 1971. An objective method for forecasting winds over Lake Erie and Lake Ontario. Abstract of paper presented at the 14th Conference Great Lakes Research, Toronto. pp. 41-42.

An objective method for forecasting surface winds over Lake Erie and Lake Ontario has been developed. The differential data consisted of 1000 mb geostrophic wind forecasts from the Subsynoptic Advection Model (SAM) for eight U. S. cities near the two lakes, as well as marine observations (MOABS) made by anemometer-equipt vessels during the 1968-69 boating season. Two sets of wind speed forcast equations were derived by applying a screening regression technique. The first set of equations yields wind speed by vectorial addition of two directional components; the second set yields wind speed directly. Verification shows that wind speed forcasts made by combining components are negatively biased. The resulting operational program is described.

26. Barrows, H. K. and A. H. Horton. 1907. Surface water supply of Great Lakes and St. Lawrence River drainages - 1906. U. S. Geological Survey Water Supply Paper and Irrigation Paper No. 206 (1-6): 1-98.

Precipitation, evaporation, tributary flow, inflow from the Niagara River and outflow from the St. Lawrence River all effect the surface water supply of Lake Ontario and the same parameters affect all the supply of the Great Lakes System. Each is discussed separately and then all combined to give the overall picture of effects on the surface water supply.

Beeton, A. M. - See: J. E. Gannon, No. 176.

27. Beeton, A. M. 1962. Light penetration in the Great Lakes. Proceedings 5th Conference Great Lakes Research, Ann Arbor, Michigan. p. 68-77.

Measurement has been made of incident and subsurface light intensities at several depths in Lakes Erie, Michigan, Huron, Ontario and Superior. At least one study was made of spectral distribution of ambient irradience in each of the Lakes. Blue light penetrated to the greatest depths in Lake Huron, green in Lakes Superior and Michigan and orange in Lakes Erie and Ontario. Measurements were made of the changes in light intensities at several depths from sunrise to sunset in Lakes Erie and Michigan and Frains Lake, a small inland lake. The percentage of incidence irradience at depth was greatest at sunrise and sunset in Lake Erie and Frains Lake. The situation occurs since incidence irradience is shifted toward the red end of the spectrum at sunrise and sunset. Consequently, a greater percentage of the incident light was in the orange region of the spectrum that penetrates deepest in these lakes. Shorter wavelengths penetrate to greater depths in Lake Michigan.

28. Beeton, A. M. 1969. Changes in the environment and the eutrophication of the Great Lakes. In: Eutrophication causes, consequences, correctives. National Academy of Science. pp. 150-187.

A discussion of environmental changes as a result of eutrophication of Lake Ontario. Dimensional and flow volume data are presented for the Niagara River and general location and dimensions of Lake Ontario. Suspended solids are also discussed.

29. Beeton, A. M. and D. C. Chandler. 1963. The St. Lawrence Great Lakes. Limnology in North America. Univ. of Wisconsin Press, Madison, Wisconsin. pp. 535-558.

General geographic and dimensional information about the Great Lakes including Lake Ontario. A history of Lake research is also presented in this paper.

30. Bird, S. J. G. and J. L. Armstrong. 1970. Scarborough Bluffs - a recessional study. Proceedings 13th Conference Great Lakes Research, Buffalo. pp. 187-197.

The unusual geological formation known as the Scarborough Bluffs, east of Toronto, has always been of interest to scientist and layman. The severe conditions of recession of the summit and erosion of the toe have become a serious problem. The result is substancial removal of valuable land, virtually priceless because of its geographical location. The study involved research of all available literature, airphoto analysis and extensive field investigations. All possible sources of erosion and recession were examined and evaluated. Ground water was found to be of critical importance, contrary to many previous theories. The difficulties and consequences of stabolization are many and varied.

Black, S. A. - See: R. H. G. Andrews, No. 16.

31. Bolduc, P. A. 1970. The change of water level caused by the variation of the inflow outflow on Lake Ontario. Department of Energy, Mines and Resources, Ottawa. 27 p.

A numerical model was developed which was successful in analysing the change in water level caused by the relation of the inflow-outflow of Lake Ontario. It is planned to study the other causes of variation such as wind and atmospheric pressure with the same model. Work will be carried out on the combined effects of all the causes of variation. On shore meteorological data will be required as input in the model. (Canada Centre for Inland Waters).

32. Bolsenga, S. J. 1967a. Great Lakes snow depth probability charts and tables. U. S. Army Corps of Engineers, Lake Survey Report RR-5-2. 34 p.

Published information on representative or complete Great Lakes snow cover conditions in lacking. This report presents the results of snow depth probability calculations for selected stations in and near the Great Lakes basin. These calculations, in tabular and graphic form, will be valuable to the scientist, as well as the layman.

All computations are based on snow on the ground data at the end of each month. The possibility of similar studies on a weekly or even a daily basis should be considered so that the frequency and effect of individual storms might be observed. Ultimately, a forecasting system for expected depths using given sets of projected meteorological conditions should be developed.

33. Bolsenga, S. J. 1967b. Snow depth probability in the Great Lakes basin. Proceedings 10th Conference Great Lakes Research. pp. 162-170.

Snow depth probability was computed for 45 stations in the Great Lakes Basin using data on snow depth at the end of the month. Probability patterns of snow cover, for the basin and for each lake region, are presented using isoline charts, graphs and tables.

For the basin, probability charts indicate marked increases from the extreme southern to the extreme northern portion of the basin. For each lake region, the probable occurrance of selected depths is analyzed using graphs of probability as a function of station location.

34. Bolsenga, S. J. 1967c. Total atmospheric water vapor aloft over the Great Lakes basin. U. S. Army Corps of Engineers, Lake Survey Report RR 5-3. 20 p.

This report presents the results of a study on the quantity and distribution of atmospheric water vapor aloft over the Great Lakes as a part of the Ice and Snow Research Project. The study was conducted under the general direction of Dr. L. Bajorunas, Director, Great Lakes Research Center, U. S. Lake Survey and Dr. E. W. Marshall, Chief of the Ice and Snow Project.

35. Bolsenga, S. J. 1968a. Great Lakes solar attitude charts and tables. U. S. Army Corps of Engineers, Lake Survey Report TT 5-4. 110 p.

A knowledge of the solar altitude is necessary for shortwave balance studies and is also used in daylight duration and sunrise-sunset determinations. This report presents detailed electronic computer calculations of solar altitudes for the entire Great Lakes basin. Using standard astronomical equations, solar altitude was computed as a function of the latitude, solar declination and true solar time.

An analysis of solar altitudes and related quantities at the summer and winter solstices indicates wide variation from the northern to the southern portion of the basin.

36. Bolsenga, S. J. 1968b. Total albedo of Great Lakes Ice. U. S. Lake Survey, Detroit, Michigan. Bulletin B68-1. pp. 1b-3b.

Information on ice albedo is required for evaluating the winter heat budget; developing forcasting techniques and evaluating ice prevention or removal methods. Incident and reflected radiation of 8 types of ice common to the Great Lakes was measured by classical pyronometers and the output measured by potentiometer. Albedo varied from 10% for clear ice to 46% for snow ice.

37. Bolton, T. E. 1957. Silurian stratigraphy and paleontology of the Niagara escarpment in Ontario. Canada Department of Mines and Technical Surveys, Geological Survey of Canada. Memoir 289. 145 p. + plates.

This report describes the result of a detailed study of sections exposed on Manitoulin Island and along the Niagara escarpment from Niagara Falls to the Bruce Peninsula. The various groups, formations and members into which the Silurian has been divided in different parts of Ontario are described and correlations suggested on the basis of observed facies changes and paleontological evidence.

38. Brebner, A. and R. J. Kennedy. 1966. Correlation of waves and shore winds, Lake Ontario. Proceedings 5th Conference Great Lakes Research, Great Lakes Research Division, Univ. of Michigan, Ann Arbor, Michigan. pp. 116-123.

Wave characteristics at any geographical location are a function of the meteorology of the surrounding area. Mathematical and graphical correlations are drawn from data concerning the relationships of meteorological conditions, especially wind direction and velocity and wave direction and height. It is pointed out that the correlation only holds true for larger waves due to the variability of lower intensity winds.

Brodfeld, B. - See: R. W. Gunwaldsen, No. 194.

Broughton, J. G. - See: D. W. Fisher, No. 172.

39. Broughton, J. G., D. W. Fisher, W. Isachsen and L. V. Richard. 1962. The geology of New York State. New York State Museum and Science Service, Map and Chart Series No. 5. 42 p. + charts.

Included is a discussion of the following geologic time periods: Pleistocene, Precambrain, Paleozoic, Mesozoic and Cenozoic. Parameters include topography, rock types, structural geology, physiographic provinces and tertiary history. Also included is a discussion of economic mineral deposits divided according to non-metals, metals and mineral fuels.

40. Browzin, B. S. 1962. On classification of rivers in the Great Lakes - St. Lawrence Basin. Proceedings 5th Conference Great Lakes Research, Great Lakes Research Division, Univ. of Michigan. pp. 86-92.

The relationship of runoff, topography and drainage in relationship to the flow volume of a river. The flow volume and its various characteristics and changes are used as the major classification factor for the Great Lakes Rivers including the St. Lawrence River.

41. Browzin, B. S. 1966. Annual runoff in the Great Lakes - St. Lawrence basin. Proceedings 9th Conference Great Lakes Research, Great Lakes Research Division, Univ. of Michigan. Publication 15. pp. 203-220.

The annual runoff of the Great Lakes - St. Lawrence basin, expressed in terms of unit runoff, increases from southwest to northeast approximately six times, which is an unusual characteristic of a river basin. The responsible factors, precipitation and its seasonable distribution, as well as mean annual temperature vary considerably but not gradually from the middle west portion of the basin to the coast of the Atlantic. Frequency analysis based on available data at gauging stations located in various climatic zones of the basin has shown that the frequency distribution of the annual runoff is moderate to low as compared to other basins with similar geographic conditions.

Bruce, J. P. - See: D. V. Anderson, No. 11

42. Bruce, J. P. 1959. Rainfall intensity-frequency maps for Canada. Department of Transport, Meteorological Branch, Canada. Circular 3243, Tec. 308. 27 p.

It is not surprising that one of the most common requests for climatological information received by the Meteorological Branch is for recurrence frequencies of short duration rainfalls of high intensities. Engineers make frequent use of such data in dealing with drainage problems. Road culverts, storm sewers, farm pond dams, airport drainage facilities, roof drainage and flood control programs on small streams are all designed on the basis of a flood of a specific average return period derived from the rainfall intensity for such a return period. Other applications of such rainfall frequency figures are in problems of soil erosion, microwave transmission, air pollution washout, etc. (Univ. of Toronto, Great Lakes Institute).

43. Bruce, J. P., D. F. Anderson and G. K. Rodgers. 1961. Temperature, humidity and wind profiles over the Great Lakes. Great Lakes Research Division, Publication No. 7. Univ. of Michigan. pp. 65-70.

This preliminary report on measurement of temperature, humidity and wind profiles by means of the new meteorological boom on the research vessel, Porte Dauphine suggests that considerable effort must yet be put forward to convert the readings into reliable profiles. A single instrument such as mounted on the bow of the Porte Dauphine affords a movable, multiple reading device which can take instantaneous samples of several parameters without accuracy loss due to time or position intervals.

44. Bruce, J. P. and G. K. Rodgers. 1962. Water balance of the Great Lakes system. In: Great Lakes Basin. American Association Advancement of Science. Publication No. 71. pp. 41-70.

The water balance of the Great Lakes system depends on precipitation, evaporation, inflow and outflow volumes. Computations of evaporation from Lake Ontario by mass transfer and energy budget methods are presented. The estimated annual evaporation from Lake Ontario is 2.8 feet.

45. Brunk, I. W. 1964. Hydrology of Lakes Erie and Ontario. Proceedings 7th Conference on Great Lakes Research, Great Lakes Research Division, Univ. of Michigan. pp. 205-216.

A study of the hydrologic characteristics of the Erie and Ontario basins indicates significant differences. In the Erie basin only about 1/3 of the precipitation becomes stream flow - apparently the lowest proportion for any of the Great Lakes basins. In the Ontario basin the stream flow is equivalent to approximately 1/2 of the precipitation. It appears that factors other than climate are responsible for these differece in hydrologic characteristics. There is a large variation in the various river basins which drain into Erie and Ontario, and also in the months of the year, in the percentages of the precipitation which flows into the lakes. The monthly extremes for Lake Erie range from 75% in March to only 8% in September. For Ontario, the figures are 117% in April to 17% in August. The water area of Lake Erie makes little contribution to the total water supply of the Great Lakes, because the average annual evaporation of approximately 34 inches is about the same as the average annual precipitation on the water surface of the lake. The average monthly evaporation from Lake Erie is largest in October - about 6 1/2 inches. For Lake Ontario, the apparent average annual evaporation is between 29 and 30 inches.

Brutsaert, W. - See: S. L. Yu, No. 438.

46. Brutsaert, W. and S. L. Yu. 1969. Hydrologic analyses for Lake Ontario: Stochastic aspects of evaporation. Cornell University Water Resource and Marine Sciences Center, Ithaca, New York. Technical Report No. 12. Various pages.

Monthly mean values of evaporation from Lake Ontario for the period from 1872 to 1965 inclusive were generated by a mass-transfer procedure. Available on-shore recorded meteorological data were adjusted to obtain approximate over-lake values with empirically derived equations. The mass-transfer coefficient was calculated by using an equation, proposed by Horbeck (1962), relating the coefficient with water surface area. A comparison of the generated mass-transfer evaporation data with water-budget estimates obtained by Morton (1967) revealed that on the average, the two methods gave comparable results. (Canada Centre for Inland Waters).

47. Bubeck, R. C., W. H. Diment, B. L. Deck, A. L. Baldwin and S. D. Lipton. 1971. Runoff of deicing salt: Effect on Irondequoit Bay, Rochester, New York. Science. 172: 1128-1132.

Salt used for deicing the streets near Rochester, New York, has increased the chloride concentration in

Irondequoit Bay at least five-fold during the past two decades. During the winter of 1969-70, the quantity and salinity of the dense runoff that accumulated on the bottom of the bay was sufficient to prevent complete verticle mixing of the bay during the spring. Comparison with 1939 conditions indicates that the period of summer stratification has been prolonged a month by the density gradient imposed by the salt runoff.

48. Buehler, E. G. 1966. Geology of Western New York - guide book. New York State Geological Association, 38th Annual Meeting. State University of New York at Buffalo. 116 p.

A compilation of many technical articles on the evolution and geology of specific rock formations found in Western New York. The major articles presented are:

1. Pre Clinton Rocks in the Niagara Frontier - D. W. Fisher.
2. Middle Silurian Clinton Relationships of Western New York and Ontario - W. J. Kilgour.
3. The Lockport Formation in Western New York - D. H. Zenger.
4. Upper Silurian Series, Niagara Frontier, New York - L. V. Rickard.
5. Bois Blanc and Onondaga Formations in Western New York and Adjacent Ontario - W. A. Oliver, Jr.
6. The Hamilton Group in Western New York - E. J. Buehler.
7. Upper Dovonian Stratigraphy and Paleonlology of Southwestern New York State (Erie, Chautauqua, Cattaraugus Counties) - I. H. Tesmer.
8. Goniatite Zonation of the New York State Dovonian - M. R. House.
9. Late Pleistocene History of Northwestern New York - P. C. Calkin.
10. The Economic Geologic Setting of Western New York - J. S. King.
11. The Gypsum Deposits of the Salina Group of Western New York - C. V. Clemency.

(Schoellkopf Museum, Niagara Falls, New York).

49. Caley, J. F. 1940. Palaeozoic geology of the Toronto-Hamilton area, Ontario. Geological Survey of Canada. Memoir 224. 284 p.

A documented and detailed map of the western shore of Lake Ontario between Niagara-on-the-Lake and Bronte, Ontario showing prominent geological characteristics.

50. Campbell, N. J. and R. K. Lane. 1967. Federal limnological research program on Lake Erie and Lake Ontario. In: Water for Peace. United States Government Printing Office. 4: 627-630.

In 1966, the Canadian Department of Energy, Mines and Resources began an investigation of heat budget, distribution and storage in Lake Erie and Lake Ontario. The article discusses data and methods but draws no conclusions. Future study plans are discussed in this area.

51. Canada Centre for Inland Waters. 1969a. Lake Ontario limnological data report No. 1, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 40 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Government of Canada agencies.

This report contains water quality data obtained on two cruises of Lake Ontario. The first cruise (a) extended from June 1-5, 1966, and consisted of 35 sampling locations siutated on the eastern end of the lake. The second cruise (b) was made fron June 7-10, 1966, and 39 sampling locations were established over the entire lake except the extreme west end.

52. Canada Centre for Inland Waters. 1969b. Lake Ontario limnological report No. 2, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 54 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Government of Canada agencies.

This report contains data on water quality obtained on a single cruise extending from June 15-19, 1966, on the Eastern end of Lake Ontario.

53. Canada Centre for Inland Waters. 1969c. Lake Ontario limnological data report No. 3, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 88 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Government of Canada agencies.

This report contains water quality data obtained on a single cruise extending from June 21-25, 1966, and covering the entire lake.

54. Canada Centre for Inland Waters. 1969d. Lake Ontario limnological data report No. 4, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 113 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains water quality data obtained on a single cruise extending from June 26-30, 1966, and covering the area along the American shoreline with the exception of the far western end of the lake.

55. Canada Centre for Inland Waters. 1969e. Lake Ontario limnological data report No. 5, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 125 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

Data of Lake Ontario water samples collected on a single, lakewide cruise extending from July 4-10, 1966, are tabulated in this report.

56. Canada Centre for Inland Waters. 1969f. Lake Ontario limnological data report No. 6, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 116 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains water quality data obtained on two cruises of Lake Ontario. The first cruise (a) extended from July 12-15, 1966, and consisted of 75 sampling locations situated over the entire lake except for the far eastern end. The second cruise (b) was made from July 19-24, 1966, and 88 sampling stations were established over the entire lake.

57. Canada Centre for Inland Waters. 1969g. Lake Ontario limnological data report No. 7, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 113 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains water quality data obtained on two cruises of Lake Ontario. The first cruise (a) extended from July 26-29, 1966, and consisted of 62 sampling locations centered around two points on either side of mid lake. The second cruise (b) was made from August 2-7, 1966, and 79 sampling stations were established over the entire lake.

58. Canada Centre for Inland Waters. 1969h. Lake Ontario limnological data report No. 9, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 119 p.

This report is one of a series listing chemical, bacteriological and physical data for Lake Ontario observed by Canadian Government agencies.

This report contains extensive water quality data obtained on two cruises of Lake Ontario. The first cruise (a) occured in the period of August 15-19, 1966, and involved 69 samplings located lakewide. The second cruise (b) extended from August 29 - September 2, 1966, and consisted of 47 sampling locations situated around the Lake.

59. Canada Centre for Inland Waters. 1969i. Lake Ontario limnological data report No 10, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 80 p.

This report is one of a series listing chemical, bacteriological and physical data from Lake Ontario observed by Canadian Government agencies.

This report contains water quality data obtained from two cruises of Lake Ontario. The first cruise (a) took place between September 6-11, 1966, and covered the area around Toronto, midlake, and an extensive section of the eastern end of the lake. The second (b) cruise extended from September 12-16, 1966, and was lakewide.

60. Canada Centre for Inland Waters. 1969j. Lake Ontario limnological data report No. 11, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 109 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains data of water samples collected on a single cruise extending from September 20-24, 1966, around the mouths of Niagara, Oswego, Genesee and St. Lawrence Rivers.

61. Canada Centre for Inland Waters. 1969k. Lake Ontario limnological data report No. 12, 1966. Canadian Oceanographic Data Centre, Burlington, Ontario. 73 p.

This report is one of a series listing data from chemical, bacteriological and physical studies of waters of Lake Ontario, observed by Canadian Government agencies.

This report contains water quality data obtained on two cruises of Lake Ontario. The first (a) extended from September 26-29, 1966, and was lakewide. The second (b) extended from October 1-3, 1966, and covered the eastern end of the lake.

62. Canada Centre for Inland Waters. 1970a. Lake Ontario limnological data report No. 1, 1967. Canadian Oceanographic Data Centre, Burlington, Ontario. 212 p.

This report is one of a series listing chemical, bacteriological and physical data from water samples from Lake Ontario, observed by Canadian Government agencies.

This report contains data of water samples collected on three lakewide cruises. The first cruise (a) consisted of 73 sampling stations, the second (b) of 73 and the third (c) of 62.

63. Canada Centre for Inland Waters. 1970b. Lake Ontario limnological data report No. 2, 1967. Canadian Oceanographic Data Centre, Burlington, Ontario. 232 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains data of water samples collected on two lakewide cruises. The first (a) extended from July 25-30, 1967, and the second (b) from August 5-10, 1967.

64. Canada Centre for Inland Waters. 1970c. Lake Ontario limnological data report No. 3, 1967. Canadian Oceanographic Data Centre, Burlington, Ontario. 179 p.

This report is one of a series listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains data of water samples collected on three lakewide cruises. The first cruise (a) extended August 21-25, 1967, the second (b) from September 5-9, 1967 and the third (c) from September 16-21, 1967.

65. Canada Centre for Inland Waters. 1970d. Lake Ontario limnological data report No. 4, 1967. Canadian Oceanographic Data Centre, Burlington, Ontario. 203 p.

This report is one of several listing chemical, bacteriological and physical data for waters of Lake Ontario, observed by Canadian Government agencies.

This report contains data of water samples collected on three lakewide cruises. The first cruise (a) extended from October 1-6, 1967, the second (b) from October 17-21, 1967 and the third (c) from October 28 - November 2, 1967.

66. Canada Centre for Inland Waters. 1970e. Lake Ontario limnological data report No. 1, 1968. Canadian Oceanographic Data Centre, Burlington, Ontario. 85 p.

This report is one of several listing chemical, bacteriological and physical data for Lake Ontario waters by Canadian Government agencies.

This report contains data of water samples collected on three lakewide cruises. The first cruise (a) extended from April 30 - May 3, 1968, the second (b) from May 27-30, 1968 and the third (c) from July 2-6, 1968.

67. Canada Centre for Inland Waters. 1970f. Lake Ontario limnological data report No. 2, 1968. Canadian Oceanographic Data Centre, Burlington, Ontario. 66 p.

This report is one of several listing chemical, bacteriological and physical data for Lake Ontario waters by Canadian Government agencies.

This report contains data of water samples collected on three lakewide cruises. The first cruise (a) extended from July 23-28, 1968, the second (b) from August 19-22, 1968 and the last (c) from September 8-13, 1968.

68. Canada Centre for Inland Waters. 1970g. Lake Ontario limnological data report No. 3, 1968. Canadian Oceanographic Data Centre, Burlington, Ontario. 100 p.

This report is one of several listing chemical, bacteriological and physical data for Lake Ontario waters observed by Canadian Government agencies.

This report contains data of water samples collected on three lakewide cruises. The first cruise (a) extended from October 5-9, 1968, the second (b) from October 27-31, 1968 and the last (c) from November 17-22, 1968.

69. Canadian Department of Energy, Mines and Resources. 1964. Great Lakes water levels. Inland Waters Branch, Great Lakes Division, Ottawa. 14 p.

The major source of water in the Great Lakes is from precipitation and stream runoff. Water elevation is relatively stable with slight yearly and cyclical seasonal lake level variation. In 1958, as part of the St. Lawrence seaway project, dams were built at the outflow of Lake Ontario which have since that time regulated and stabilized lake level.

Three interbasin diversions operate in the Great Lakes, the Long Lac and Ogahi diversions that channel water from Hudson Bay tributaries into Lake Superior and the Chicago diversion that takes water from Lake Michigan and puts it into the Mississippi basin.

Water level control by diversion and daming outflows has, therefore, relatively stabalized the lake levels allowing for partial human control. (Canada Centre for Inland Waters).

70. Canadian Department of Energy, Mines and Resources. 1966. Ontario surface water data. Water Survey of Canada, Ottawa. 277 p.

Data on tributaries to Lake Ontario. Parameters discussed are: location, drainage area, apparatus, period of record, discharge. The volume parameters are given daily and monthly.

71. Canadian Department of Energy, Mines and Resources. 1967a. Ontario surface water data. Water Survey of Canada, Ottawa. 303 p.

Data on tributaries to Lake Ontario. Parameters discussed are: location, drainage area, gauge apparatus, period of record, discharge/day/month.

72. Canadian Department of Energy, Mines and Resources. 1967b. Water levels, 1966. Great Lakes St. Lawrence River System. Inland Waters Branch, Ottawa. Vol. 1. 345 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

73. Canadian Department of Energy, Mines and Resources. 1968. Water levels, 1967. Great Lakes St. Lawrence River System. Inland Waters Branch, Ottawa. Vol. 1. 187 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

74. Canadian Department of Fisheries and Forestry. 1969. Water levels, 1968. Great Lakes St. Lawrence River System (non-tidal). Marine Science Branch, Ottawa. Vol. 1. 191 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

75. Canadian Department of Fisheries and Forestry. 1970. Water levels, 1969. Great Lakes St. Lawrence River System (non-tidal). Marine Science Branch, Ottawa. Vol. 1. 195 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

76. Canadian Department of Fisheries and Forestry. 1971. Water levels, 1970. Great Lakes St. Lawrence River System (non-tidal). Marine Science Branch, Ottawa. Vol. 1. 199 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

77. Canadian Department of Mines and Technical Surveys. 1963. Water levels, 1962. Great Lakes St. Lawrence River System, Atlantic Coast and Artic Coast. Marine Science Branch, Ottawa. 95 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

78. Canadian Department of Mines and Technical Surveys. 1964. Water levels, 1963. Great Lakes St. Lawrence River System, Atlantic Coast, Hudson Bay and Artic Waters and Pacific Coast. Marine Science Branch, Ottawa. 170 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

79. Canadian Department of Mines and Technical Surveys. 1965. Water levels, 1964. Great Lakes St. Lawrence River System, Atlantic Coast, Hudson Bay and Arctic Waters, Pacific Coast. Marine Science Branch, Ottawa. 270 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

80. Canadian Department of Mines and Technical Surveys. 1966. Water levels, 1965. Great Lakes St. Lawrence River System (non-tidal). Marine Science Branch, Ottawa. Vol. 1. 166 p.

The water levels compiled in this book were tabulated from continuous records obtained throughout the year. Data include daily and monthly means, high and low water levels and high and low tide levels.

81. Canadian Department of Northern Affairs and National Resources. 1960. St. Lawrence and southern Hudson Bay drainage - 1956-57. Water Resources Paper No. 119, Ottawa. 544 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Credit River
Etobicoke River
Trent River
Depot Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River
Duffin Creek
Ganarasha River
Nepanee River
Mocra River with Skootamatta River and Black River

82. Canadian Department of Northern Affairs and National Resources. 1962a. St. Lawrence and southern Hudson Bay drainage - 1957-58. Water Resources Paper No. 126, Ottawa. 326 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Credit River
Etobicoke River
Trent River
Depot Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River
Duffin Creek
Ganarasha River
Nepanee River
Mocra River with Skootamatta River and Black River

83. Canadian Department of Northern Affairs and National Resources. 1962b. St. Lawrence and southern Hudson Bay drainage - 1958-59. Water Resources Paper No. 129, Ottawa. 328 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Credit River
Etobicoke River
Trent River
Depot Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River
Duffin Creek
Ganarasha River
Nepanee River
Mocra River with Skootamatta River and Black River

84. Canadian Department of Northern Affairs and National Resources. 1963. St. Lawrence and southern Hudson Bay drainage - 1959-60. Water Resources Paper No. 133, Ottawa. 352 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Credit River
Etobicoke River
Trent River
Depot Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River
Duffin Creek
Ganarasha River
Napanee River
Mocra River with Skootamatta River and Black River

85. Canadian Department of Northern Affairs and National Resources. 1964. St. Lawrence and southern Hudson Bay drainage - 1960-61. Water Resources Paper No. 137, Ottawa. 376 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Credit River
Etobicoke River .
Trent River
Depot Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River
Duffin Creek
Ganarasha River
Nepanee River
Mocra River with Skootamatta River and Black River

86. Canadian Department Northern Affairs and National Resources. 1965. St. Lawrence and southern Hudson Bay drainage - 1962-63. Water Resources Paper No. 143, Ottawa. 352 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Credit River
Etobicoke River
Trent River
Depot Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River
Duffin Creek
Ganarasha River
Napanee River
Mocra River with Skootamatta River and Black River

87. Canadian Department of Northern Affairs and National Resources. 1966. St. Lawrence and southern Hudson Bay drainage water year 1963-64. Water Resources Paper No. 147, Ottawa. 368 p.

The report contains discharge and runoff data for the following rivers in the Ontario Basin.

Niagara River
Welland River
Twenty Mile Creek
Oakville Creek
Humber River and Branches
Dan River
Highland Creek
Rouge River

Credit River
Etobicoke River
Trent River
Depot Creek
Duffin Creek
Ganarasha River
Nepanee River
Mocar River with Skootamatta
River and Black River

88. Canadian Department of Transport. 1959a. Break-up and freeze-up dates of rivers and lakes in Canada. Meteorological Branch Circular 3156, Ottawa. Ice 2. 91 p.

The time at which ice in rivers and lakes breaks up in the spring, and reforms again in the fall, is of great importance to many public and private agencies. Ice is of particular concern to ship operators, fishermen, aircraft operators, logging interests and power companies.

The dates of break-up and freeze-up of rivers and lakes in the immediate vicinity of meteorological stations have been obtained for past years for as long a period as possible. The results from the survey are listed in this publication. Data on break-up and freeze-up has been obtained for 87 rivers, and 113 lakes, bays and harbours. The length of the individual records varied from one year, to 128 years for the Miramichi River at Chatham, N. B., and 130 years for the St. John River at Fredericton, N. B.

The information on break-up indicated the data on which the ice first moved or showed signs of breaking, and also the date on which the water was entirely clear of ice. Similarly for freeze-up, the date on which ice first formed and the date on which the body of water was completely frozen over was listed. Data was obtained from a wide variety of sources including station meteorological records, newspaper files, power companies, public utility companies, harbour commissions, transportation companies, church missions, RCMP., other governmental agencies and many private companies and individuals.

Since the original survey, a regular program for the reporting of dates of break-up and freeze-up at selected meteorological stations has been instituted. Additional data obtained as a result of this program will be published when available.

The following tables list all the data concerning break-up and freeze-up in Canada, which is presently available to the Meteorological Branch. Where the length of record is ten years or more, mean dates are given, and extreme dates are underlined. (Univ. of Toronto, Great Lakes Institute).

89. Canadian Department of Transport. 1959b. Maximum winter ice thinkness in rivers and lakes in Canada. Meteorological Branch Circular 3195, Ottawa. Ice-4. 19 p.

As the result of a survey of Canadian Meteorological stations in 1956 and 1957, and a continued reporting program by stations since that time, the dates of break-up and freeze-up of 195 rivers and lakes in Canada were obtained for varying number of years. The results of this survey were published in Circular 3156 ICE-2 30 Jan. 59. In this report, meteorological stations were also requested to report the maximum winter ice thickness which attained in the body of water concerned, if this information could be obtained.

The ice thickness data has been collected for 78 lakes and 42 rivers at 125 locations in Canada, and is listed in this circular. In most instances, data are available for 1957 and 1958 only, but six stations have provided data for periods exceeding 15 years. (Univ. of Toronto, Great Lakes Institute).

90. Canadian Department of Transport. 1964. Aerial ice observing and reconnaissance. Meteorological Branch, Great Lakes Circular 3987, Ottawa. Ice-13. 25 p.

This is the twenty-second report in the series concerning ice conditions observed by aerial ice reconnaissance conducted by the Basic Weather Division, Meteorological Branch, Department of Transport.

This report described observed ice conditions, with regard to ice coverage, age, topography, puddling, snow cover and water features over the area of Lake Superior, the North Channel, Georgian Bay, Lake Huron, Lake Erie, Lake Ontario and adjacent waterways, during the period December, 1962 to April, 1963. (Univ. of Toronto, Great Lakes Institute).

91. Canadian National Committee. 1967. Canadian research basin. Ottawa, Ontario. Unnumbered.

Basic data on a few smaller tributary basins flowing into Lake Ontario. Location, elevation water flow, development and experimentation parameters are discussed. (Canada Centre for Inland Waters).

92. Cartier, R. H. 1968. Pollution, oceanography and limnology in the Great Lakes. 17th International Congress of Limnology, Jerusalem, Israel. pp. 60-68.

A listing of research parameters to be investigated by various research organizations during the International Field Year-Great Lakes. They include:

1. Lake Meteorology - evaporation, aerial distribution of precipitation, air-water interface, definition of lake wind-field, lake influence on atmosphere and climate.
2. Reassessment of water budget terms - inflow, outflow, precipitation, evaporation, ground water contribution, soil moisture levels, diversing and consumptive use.
3. Energy Balance - energy exchange, transport and thermal characteristics.
4. Water Movement - currents, seiches, waves, diffusion, shore and bottom processes.
5. Interdisciplinary Problems - water levels.

93. Chalmers, R. 1905a. Changes in the levels of the Great Lakes. Geological Survey of Canada. Annual Report (New Series). 14: 169A.

It is evident that Huron, Erie and Lake Ontario stood at higher levels at the close of the Pleistocine period than they do at present time. In the subsistence of the waters that followed, the various lakes reached a level considerably lower than present levels. This low level stage probably occurred in the Recent Period, that is, since the latest of the Pleistocene beds were laid down. In the Lake Ontario Basin, the Humber, Don and the Cataraqui at Kingston have the lower parts of their courses flooded from the lakes. The lake must have been 25-30 ft. lower at the time to allow for the channel erosion.

94. Chalmers, R. 1905b. Sand dunes and spits. Geological Survey of Canada. Annual Report (New Series). 14: 170A.

In the Lake Ontario Basin, the sand driftage has been from east to west. Toronto Island and Burlington Beach may have been formed by this movement. These beach formations exemplify the conditions which prevailed in the interglacial period in this region when land and fresh water shells were buried together in the clay and sand beds of that time.

Chandler, D. C. - See: A. M. Beeton, No. 29.

95. Chandler, D. C. 1964. The St. Lawrence Great Lakes. Great Lakes Verh. Internat. Verin. Limnol. 15: 59-75.

General geographical, morphometric and limnological data pertaining to the Great Lakes. Included is a listing of contemporary research and funding organizations and programs.

96. Chapman, L. J. and D. F. Putnam. 1937. The soils of south central Ontario. Sci. Agr. 18(4): 161-197.

The southern part of Central Ontario has an interesting and, in some respects, unusual set of soils. Because of the complex geological history of the parent materials, the types are many and varied; hence a complete classification of all the members and an accurate mapping of the same will come only with a detailed soil survey. In the meantime, it is useful to have a general description embodying those physical factors, such as topography, drainage, depth and stoniness, which limit theuse of land, as well as those factors of natural fertility which govern soil treatments. Finally by taking into consideration the morphological features of the soil profiles, and by grouping those types which show similarity in the chief characteristics, it is possible to classify thirteen land types which constitute fairly well define units in the study of agricultural adaptation. It is, therefore, to be hoped that this account of the soils of south-central Ontario will serve the purposes of geographers and ecologists, and until more detailed soil surveys are made, will constitute a guide to soil treatments, as well as a basis upon which to plan actual tests with fertilizers and different varieties of crop plants. (Univ. of Toronto, Zoology Library).

97. Chapman, L. J. and D. F. Putnam. 1939. The physiography of eastern Ontario. Sci. Agr. 20(7): 424-441.

Eastern Ontario comprises that part of the St. Lawrence lowland lying within the Province east of Kingston. It is largely underlain by sedimentary rock of the Ordovician system which have departed but little from their original horizontal attitude, but it also includes the more low-lying border areas of the Laruential Shield, some of which were undoubtedly covered, before glaciation, by sedimentary rock. Subsequent to glaciation, it was drowned by the sea and so its surface in part is now covered by unconsolidated deposits, but there are large areas of very shallow drift and rock outcrop.

In some instances, the same type of topography and surface deposit are present in continuous areas of several hundred square miles, while other sections are much less uniform and consist of a patchwork of several types. We have not attempted to name and describe individually each of the smaller units but they have been classified and mapped under seven categories, the chief characteristics of which have been summarized in Table 1.

As was the case in Central Ontario (13), the present study was undertaken to provide a basis for the classification of surface geological materials in the course of reconnaissance soil survey. It has been shown in South-Central Ontario (1) and in South-Western Ontario, as well, (12) that a strong correlation exists between the geological materials and the chemical properties of the soils developed from them. This is in accordance with the well known pedological principal that young soils exhibit more of the characteristics of the parent materials than do more mature soils in which the zonal or climatically determined features are predonimant.

98. Chapman, L. J. and D. F. Putnam. 1942. The soils of eastern Ontario. Sci. Agr. 22(10): 608-636.

The soils of Eastern Ontario are younger than those of Central and Southwestern Ontario, hence leaching has proceeded for a shorter length of time. However, this is counter-balanced by a colder climate which results in more severe leaching here, especially up the Ottawa Valley where coniferous forests are found.

As a result of level topography, drainage is poor in about half of the area, constituting a major problem for the farmers of the region. On higher sites, the most obnoxious characteristic is stoniness. Some of the best land was originally either poorly drained or stony. The poor land is made up of the shallow, sandy, wet and stony, or excessively stone soil and bog. On this basis, there is more poor land than good, the aereal ratio being about 60 to 40.

The chemical nature of the soils were studied through a collection of 464 samples taken from hay and pasture fields. After testing these samples, it is possible to point out the soils with the most, least and an intermediate amount of lime, phosphate or potash. Furthermore, an attempt was made to divide the area into zones with similar fertilizer and lime requirements. The need of experimental work in certain cases is also indicated and those soils considered unworthy of expensive treatment under present economic conditions are also mapped.

An added item of description is the table of numerical ratings for each type of land as to its ability to produce several staple crops. It is intended that more specific studies will be made on the adaptation of crops; that is, one of the main reasons for making this survey of the soils. (Univ. of Toronto, Zoology Library).

99. Chapman, L. J. and D. F. Putnam. 1943. The moraines of southern Ontario. Transactions Royal Society of Canada. Section 4: 33-41.

The moraines north of Lake Ontario were formed by the actions of two ice masses, one in the Lake Ontario Basin, the other advancing from the north. The action and interaction produced several prominent moraines in the area. Discussed are the Oak Ridges and Scaroborough Moraines.

100. Chawla, V. K. and J. W. Traversy. 1968. Methods of analysis on Great Lakes waters. Proceedings 11th Conference Great Lakes Research. pp. 524-530.

Methods of the analytical section, Water Quality Division, were used to analyze Great Lakes waters aboard ship and on the shore based laboratory, Burlington, Ontario, where both Lake Erie and Lake Ontario waters were analyzed.

At Lake Ontario, three stations were established where samples were taken at descending depths-two samples/depth and were analyzed for specific conductance. The results are in a table.

101. Chermack, E. E. 1970. Study of thermal effluents in southeastern Lake Ontario as monitored by an airborne infrared thermometer. Proceedings 13th Conference, Great Lakes Researc. pp. 904-913.

Commensing in July, 1969, and continuing into the 1969-70 winter, twice weekly measurement of lake surface temperatures off the southeastern shore of Lake Ontario have been made using a Barnes PRT-5 radiation thermometer mounted on a small aircraft. The object of this research was to obtain data on the present effluents into the lake power plants, and to obtain background information on the undisturbed lake prior to introduction of new effluents.

Over one half years data has been analyzed. Maps of the Oswego River and two new power plant effluents are presented and discussed.

Clark, J. R. - See: P. F. Karrow, No. 228.

102. Clark, L. J. 1891. Currents in Lake Ontario. Transactions Canadian Institute. 3: 275-280.

A general discussion of Lake currents (surface and internal) along with the factors responsible for the generation of such currents. A float was used to tabulate current velocity and direction. Instances are presented supporting the theory of strong undercurrents in the lake.

103. Clark, L. J. 1892. Currents in Lake Ontario. Transactions Canadian Institute. 2: 154-157.

Currents in Lake Ontario do not follow a regular, constant, well defined pattern. The currents are a result of varying winds, precipitation and atmospheric pressure which vary greatly from month to month and year to year. The study of the currents in the Rochester area of U. S. and Scarborough area of Canada are used. The author discusses his theory of undercurrents or undertow currents and relates some shipping phenomenon to the existence of these.

104. Claypole, E. W. 1881a. Origin of Lakes Erie and Ontario. Canadian Naturalist. 9: 213-227.

The glacial theory on the origin of the Great Lakes basin rests on insufficient evidence. The glaciers could not have eroded so much material, the eroded material is not found where it should be found if the theory was true, and there could have been no local glaciers had the Lake beds not previously existed to hold them.

Therefore, the river theory should be considered due to less explanitory difficulty. Lakes Huron, Erie and Ontario were formed by widening of areas in a large pre-glacial river.

105. Claypole, E. W. 1881b. Evidence from the drift of Ohio, Indiana and Illinois, in support of the preglacial origin of the basins of Lakes Erie and Ontario. Proceedings of the American Association for the Advancement of Science. 30: 147-159.

The glacial theory is not sufficient to explain the Great Lakes Basin formation. The glaciers could not have done the necessary erosion, the deposits are not in the right position or volume to have been done by the glacier, and there could have been no glacial action in the area, had the beds not already existed. The basins, therefore, are thought to be the result of an ancient river with the bottling up phenomenon produced by the glaciers.

106. Claypole, E. W. 1886. The old gorge at Niagara. Science. 8: 236.

The author hypothesizes that a limestone ridge or block in the old St. Davids Gorge is an indication that the Niagara River did not flow through the Gorge as has been believed but the present "St. Davids Gorge" which is now almost entirely filled in by glacial deposits was formed by a second river flowing into the Niagara, joining it at the whirlpool section of our present Niagara River.

107. Coakley, J. P. 1970. Natural and artificial sediment tracer experiments in Lake Ontario. Proceedings 13th Conference Great Lakes Research. pp. 198-208.

Thin sand bodies of intermediate surface area overlying bedrock and glacial deposits occur at intervals in the nearshore zone of western Lake Ontario between Burlington and Toronto. Natural tracers, i.e. textural and mineralogical characteristics of the sediments, and artificially fluorescent sand were used to study transport direction and sediment provenance in this area. The minerals in the sand bodies were characterized by angularity and a high proportion of non-resistent minerals. Statistical tests on the samples indicated that the minerology of the sand bodies did not vary significantly from sand body to sand body. The combination of these features suggests derivation from local sources rather than one external to the area. The textural data do not contradict this conclusion, but due to the significant effect of varying water depth over the sand bodies, more careful sampling is needed to evaluate their use as sediment transport indicators. This study indicated that sediment transport direction is related primarily to the orientation of the shoreline with respect to easterly winds.

108. Coch, N. K. 1961. Textural and minerological variations in some Lake Ontario beach sands. M. S. Thesis, Univ. of Rochester. 262 p.

1. The beach sands of Lake Ontario are largely derived from the glacial deposits exposed along the shore. While a part of the light fraction is derived from the sedimentary rocks exposed along the shore, the rest of the light fraction and most (95 percent) of the heavy mineral fraction is derived from the igneous and metamorphic rocks of the Adirondacks and Greenville Province.

2. The mineralogy of the beach sands is very uniform along the interval studied, with variations between samples being due to changes in texture.

3. Glacial deposits on the convex areas are being actively eroded. The finer fraction of these deposits is transported east and deposited in adjacent concave areas.

4. Areas of active wave erosion are characterized by coarser material on the beaches and a positive slewness. The reverse is true for sheltered areas.

5. The higher percentages of hypersthene in the beach sands west of Sodus Bay suggests that the tills to the west of Sodus Bay were derived from an area richer in hypersthene, than those to the east of Sodus Bay.

6. Beach sediments which have a phi mean less than 1.70 are more poorly sorted than those sediments which have a phi mean greater than 1.70.

7. Beach sands that are well sorted have higher kurtosis values than those that are poorly sorted.

8. Better sorted sediments have a higher percentage of heavy minerals than poorly sorted sediments.

9. Sediments which have a phi mean between 1.5 and 2.5 have the highest percentage of heavy minerals.

109. Coleman, A. P. 1913. III. Geology of the Toronto region. In: Faull, J. H. (Ed.). The Natural History of the Toronto region. Canadian Institute, Toronto. p. 51-81.

Contains a study of the geology of the Toronto region. Within one hundred miles of Toronto the following geological formations are displayed:

Recent - shore cliffs and wave-built bars
Pleistocene - glacial, interglacial and post-glacial beds
Palaeozoic - (1) Devonian - onondaga and Hamilton beds.
(2) Silurian - cataract, medina, clinton, Niagara and Guelph beds.
(3) Ordovician - Trenton limestone, Utica and Collingwood shale, Lorraine shale and Queenston shale.
Archaean - granites, gneisses, greenstones and greenschists.

Included in the section on glacial lakes is a history of Niagara Falls. It tells of the formation of the Falls beginning with the outflow of the Algonquin waters through the Erie valley and northward over the Niagara escarpment into the basin of Lake Iroquois. The gorge is discussed along with the receding of the Falls.

Also included is a discussion of the soils and their formation of the Toronto region. (Toronto-Royal Ontario Museum).

110. Coleman, A. P. 1922. Glacial and post glacial lakes in Ontario. Ontario Fisheries Research Laboratory Publication, No. 10. Univ. of Toronto Studies. 76 p.

The glacial formation of several Ontario lakes throughout several geological periods is discussed. The article follows evolutionary geological transformations during the formation of the Great Lakes from preglacial times to the present. The preglacial Laurentian River and its tributaries followed the general flow pattern of the Great Lakes of today. The outlet in the Ontario basin was periodically blocked and freed during at least 5 glacial periods. The outlet rose gradually producing a deeper and larger lake. The outlet since the last glacial age has dropped approximately 25 feet lowering the lake level. Many other lakes formed by the glaciers are discussed.

111. Corps of Engineers. Undated. Study of the Lake Erie-Lake Ontario Canal. U. S. Army Corps of Engineers, Buffalo District. 5 p.

The building of new Lake Erie-Lake Ontario Canal would require: straightening, widening and deepening, the Black Rock Channel; raising or rebuilding bridges that span the Niagara River between Lake Erie and Tonawanda Harbor; a thorough review of routes that appear to be most feasible and economical between North Tonawanda and Lake Ontario; construction of railway and highway bridges over the selected route of the New Canal; and the nature and suitability of subsurface material on which the locks and structures will be built.

Shipping parameters should be investigated and an extensive cost-benefit study should be undertaken.

112. Corps of Engineers. 1951. Niagara River redevelopment. U. S. Army Corps of Engineers, Buffalo District. 15 p. and several plates.

Results of seismological testing and stress studies indicates several stress points in the bedrock of western New York. Examples of rock movements on "squeezes" are given along the Erie Canal and Niagara River. The movement appears to be primarily in the dolomites of the area with a general east-west movement. Core must be taken in tunnel or canal construction to allow for some expansion or contraction.

113. Corps of Engineers. 1955. Fair Haven Beach State Park, New York, beach erosion control study. 84th Congress, 1st Session, House Document No. 134, U. S. Government Printing Office, Washington, D. C. 40 p.

Fair Haven Beach State Park comprises about 1 1/2 miles of shore on the southern shore near the east end of Lake Ontario. It is located in the town of Sterling, in Cayuga County, about 15 miles southwest of Oswego Harbor.

The purpose of this overall study is to develop the most suitable plans for the protection of the shores of three established State parks known as Selkirk Shores State Park, Fair Haven Beach State Park and Hamlin Beach State Park, with a view to preventing further erosion of the shores within these areas and to determine the extent of Federal participation in the cost of a project for beach erosion control. The plans are to include specific areas within each park by the restoration or creation of beaches. The present report concerns Fair Haven Beach State Park only.

114. Corps of Engineers. 1955. Hamlin Beach State Park, New York, beach erosion control study. 84th Congress, 1st Session, House Document No. 138, U. S. Government Printing Office, Washington, D. C. 34 p.

Hamlin Beach State Park comprises about 2 1/4 miles of shore in the central part of the southern shore of Lake Ontario. It is located in the town of Hamlin in Monroe County, about 20 miles west of Rochester.

The purpose of this overall study is to develop the most suitable plans for the protection of the shores of three established State parks known as Selkirk Shores State Park, Fair Haven Beach State Park and Hamlin Beach State Park, with a view to preventing further erosion of the shores within these areas and to determine the extent of Federal participation in the cost of a project for beach erosion control. The plans are to include specific areas within each park by the restoration or creation of beaches. The present report concerns Hamlin Beach State Park only.

115. Corps of Engineers. 1960. Great Lakes harbors study - Interim report on Rochester Harbor, New York. 86th Congress, 2nd Session, House Document No. 409, U. S. Government Printing Office, Washington, D. C. 46 p.

Rochester Harbor is located at the mouth of the Genesee River on the south shore of Lake Ontario. This interim report considers channel deepening and widening and dredging an upstream turning basin, all in the interests of deep-draft bulk cargo traffic.

116. Corps of Engineers. 1961. Great Lakes harbors study - Interim report on Great Sodus Bay, New York. 87th Congress, 1st Session, House Document No. 138, U. S. Government Printing Office, Washington, D. C. 42 p.

Great Sodus Bay Harbor is in Great Sodus Bay located on the south shore of Lake Ontario. This interim report considers channels and turning basin deepening and enlargement, all in the interests of deep-draft bulk cargo traffic. The purpose of the report is to determine the need and the desirability of providing additional navigation improvements at Great Sodus Bay Harbor to accomodate the large bulk freight vessels anticipated to be used in the future Great Lakes traffic.

117. Corps of Engineers. 1962a. Great Lakes harbors study - Interim report on the Oswego Harbor, New York. 87th Congress, 2nd Session, House Document No. 471, U. S. Government Printing Office, Washington, D. C. 67 p.

Oswego Harbor, New York is located near the easterly end of the south shore of Lake Ontario at the mouth of the Oswego River. This interim report considers the improvement of Oswego Harbor, New York, in the interests of deep-draft navigation traffic in both bulk and general cargo. The purpose of the considered improvement is to provide access channels and a turning basin of adequate depths and dimensions to service terminal facilities in the 1,600-foot reach immediately above the mouth of the Oswego River.

118. Corps of Engineers. 1962b. Monthly bulletin of lake levels. U. S. Army Corps of Engineers, Lake Survey Detroit, Michigan. 1 sheet.

The U. S. Army Corps of Engineers monitors Great Lakes levels monthly, records and then publishes the results in a monthly bulletin. The bulletins for lake levels in past years are not available, however, a running graphic monthly and yearly level tabulation is kept at each branch office.

119. Corps of Engineers. 1965a. Water levels of the Great Lakes - report on lake regulation main report. U. S. Army Corps of Engineers, North Central District, Chicago. 57 p + appendices.

The main report of a series of reports on the necessity and effects of Great Lake level regulation. Paper includes water sources to the lakes, water outflows and removal from the lakes and the economic benefits and feasibility of lake regulation. (Univ. of Toronto, Great Lakes Institute).

120. Corps of Engineers. 1965b. Water levels of the Great Lakes - report on lake regulation appendix A - hydraulics and hydrology. U. S. Army Corps of Engineers, North Central Division, Chicago. 48 p. + appendices.

Included in this article are data on Lake and land drainage areas, tributaries, lake levels, climatology, precipitation, runoff, ground water, evaporation, ice retardation and lake water diversions. (Univ. of Toronto, Great Lakes Institute).

121. Corps of Engineers. 1965c. Water levels of the Great Lakes - report on lake regulation appendix B - lake regulation. U. S. Army Corps of Engineers, North Central Division, Chicago. 57 p. + appendices.

An in-depth discussion of the methodology involved in the regulation of lake levels of the Great Lakes. Parameters discussed are runoff, precipitation, evaporation, inflows and outflow. The effect of regulation of Lake Ontario waters on the flow volume of the St. Lawrence River is also discussed. The St. Lawrence receives more water during high lake levels and less water during low lake levels, than before the regulations came into being. (Univ. of Toronto, Great Lakes Institute).

122. Corps of Engineers. 1965d. Water levels of the Great Lakes - report on lake regulation - appendix C - effect of lake regulation on shore property. U. S. Army Corps of Engineers, North Central District, Chicago. 43 p. + appendices.

A discussion of the geology of the shore areas of the Great Lakes is followed by an in depth discussion on lake-level-shore erosion correlations. The erosion parameter includes the effects of wind on the production of waves and the effects of waves, winds, currents and runoff on the shorelines of the lakes. An economic evaluation of the regulation of water levels is also presented in this paper. (Univ. of Toronto, Great Lakes Institute).

123. Corps of Engineers. 1965e. Water levels of the Great Lakes - report on lake regulation - appendix D - effect of lake regulation on navigation. U.S. Army Corps of Engineers, North Central District, Chicago. 16 p. + appendices.

Experience on the Great Lakes has clearly demonstrated that vessel operators have always taken advantage of any increased depths provided for navigation. There are today, and it is expected that there will continue to be, vessels in the fleet which will be required to load at reduced draft, except during times when the levels of the Great Lakes are at high stages. Consequently, lake level regulation altering the regimen of lake levels by narrowing the range of extreme stages that have been experienced, through a raising of the lower levels and a reduction of the higher levels would affect Great Lakes navigation.

The tentative lake regulation study plans developed in this investigation are presented in detail in Appendix B. There is one study plan for regulation of Lake Erie, two study plans for regulation of Lake Michigan-Huron and one for the regulation of Lake Superior. The purpose of this Appendix D is to estimate the effect on navigation of regulating the levels of Lakes Erie and Michigan-Huron under the plans considered for these two lakes. The appendix presents an evaluation of effects on commercial and recreational navigation resulting from the study plan for Lake Erie regulation. The appendix develops estimates of the general magnitude of effect on navigation of regulating Lake Michigan-Huron under the study plans for that lake. (Univ. of Toronto, Great Lakes Institute).

124. Corps of Engineers. 1965f. Water levels of the Great Lakes report on lake regulation - Appendix F - regulatory works. U. S. Army Corps of Engineers, North Central District, Chicago. 24 p. + appendices.

To accomplish in some measure the several purposes of lake regulation, two facilities must be provided at the outlet of the lake that is to be regulated. First, the discharge capacity of the outlet must be increased, so that at times, larger releases of water from the lake than would occur without regulation can be made in order to reduce high lake levels. This requires channel enlargements in the outlet river or the provision of supplementary channels for augmentation of the outflow capacity. Second, a gated control structure of structures must be procided so that at other times smaller releases than without regulation can be made in order to raise low lake levels.

The tentative study plans considered in Appendix B for the regulation of Lake Michigan-Huron and Lake Erie have determined the critical combinations of regulated lake levels and outflows that is necessary to provide for, in order to make the considered regulation plans workable. For Lake Michigan-Huron the regulatory works would be provided in the St. Clair-Detroit River system; for Lake Erie, in the upper reach of the Niagara River. Modifications studied for the regulation of Lake Superior were considered on the basis of no changes to the existing works in the St. Marys River. Similarly, no changes to the works in the St. Lawrence River were contemplated in the studies of this report. (Univ. of Toronto, Great Lakes Institute).

125. Corps of Engineers. 1966. Red Creek, Genesee River Basin, Monroe County, New York. 89th Congress, 2nd Session, Senate Document No. 107, U. S. Government Printing Office, Washington, D. C. 62 p.

Red Creek, a minor tributary of the Genesee River, is located near the northern end of the river basin and has a drainage area of about 23 square miles, all in Monroe County, New York. This report concerns improvements in the Red Creek basin to satisfy present and future needs for protection from the Genesee River overflows and from floods originating within the Red Creek basin.

126 Corps of Engineers. 1967. Wilson Harbor, New York. 90th Congress, 1st Session, House Document No. 112, U. S. Government Printing Office, Washington, D. C. 59 p.

Wilson Harbor is a small-craft harbor on the south shore of Lake Ontario at the mouth of the East Branch of Twelvemile Creek in New York. Just before entering Lake Ontario, the East Branch of Twelvemile Creek flows through a shallow embayment known as Tuscarora Bay. This report considers modification of the existing Federal project to provide for a suitable channel and maneuvering area in Tuscarora Bay, and certain changes in the present requirements of local cooperation, in the interest of small-boat navigation.

127. Corps of Engineers. 1968. Hamlin Beach State Park, New York. 90th Congress, 2nd Session, House Document No. 358, U. S. Government Printing Office, Washington, D. C. 53 p.

Hamlin Beach State Park comprises about 2 1/4 miles of shore in the central part of the southern shore of Lake Ontario. It is located in the town of Hamlin in Monroe County, about 20 miles west of Rochester.

This report considers the advisability of Federal improvement to provide a small-boat harbor at Hamlin Beach State Park, New York. Such a harbor would supplement the program of small-craft harbors. This presently authorized chain of small boat harbors is primarily for the larger cruising recreational craft. The principal consideration given in the present report is to the need for an intermediate harbor to serve the smaller cruising craft, and to provide a base for additional boats.

128. Corps of Engineers. 1969a. Great Lakes and St. Lawrence Seaway navigation season extension. Department of the Army, Detroit District, U. S. Army Corps of Engineers, Detroit, Michigan. 76 p., 22 maps + plates.

A review of world wide experience in ice navigation and ice modification techniques indicates that present technology is sufficiently advanced to make winter operation on the Great Lakes - St. Lawrence Seaway system physically feasible. The extent to which winter operation should be undertaken at this time, and the economic feasibility for either limited or full 12 month extension, cannot be determined on the basis of the limited investigations made in this study. However, estimates or prospective traffic and benefits demonstrate a magnitude of economic potential which clearly indicates need for further investigation and development. The feasibility study, therefore, recommends both immediate and long-range objectives for development of an extended navigation season on the Great Lakes - St. Lawrence Seaway. (Canada Centre for Inland Waters).

129. Corps of Engineers. 1969b. Great Lakes shoreline damage. U. S. Army Corps of Engineers, North Central Division, General Information Pamphlet (Chicago). 21 p.

Part I is a history and background discussion of lake levels, causes of fluctuations and most important, effects of lake level changes on shorelines. Part II discusses the role of Federal and State Governments in various activities and responsibilities on the Great Lakes related to water and shore areas. It includes information on available data and sources of such data. Part III is a brief discussion of several emergency type remedial measures, estimates of thin cost and general statements on their applicability to various typical situations.

130. Corps of Engineers. 1970a. Beach erosion study of east end of Oneida Lake, N. Y. Prepared for the State of New York Department of Environmental Conservation, Division of Water Resources. U. S. Army Corps of Engineers, Buffalo, N. Y. Unnumbered.

Oneida Lake is located in central New York about 12 miles north-easterly of Syracuse, New York. The purpose of this beach erosion control study is to investigate the causes of reported loss of beaches and subsequent erosion damage to the shore from wave action.

131. Corps of Engineers. 1970b. South shore of Lake Ontario, Fort Niagara State Park. 91st Congress, 2nd Session, House Document No. 91-319. U. S. Government Printing Office, Washington, D. C. 56 p.

Fort Niagara State Park is located on the south shore of Lake Ontario at the mouth of the Niagara River. The purpose of this study is to develop plans for the protection and improvement of the easterly 4,000 linear feet of the Lake Ontario frontage of Fort Niagara State Park. In addition to providing protection against erosion from wave action, the State of New York wishes to restore and improve the beach for use as a public bathing beach. The economic justification of considered improvements and the extent of the Federal interest and participation in their cost are also to be determined.

132. Corps of Engineers. 1971a. Environmental statement - Oswego steam station - Unit 5, Niagara Mohawk Power Corporation. U. S. Army Corps of Engineers, Buffalo, New York. 85 p.

Data on the general lake conditions at the Oswego Steam Station (Niagara Mohawk Power Corporation). Parameters discussed in relation to physical environment are:

- Topography
- Geology
- Ground Water
- Surface Water - dimensions, runoff, precipitation, lake levels, currents, thermal gradients

133. Corps of Engineers. 1971b. Great Lakes region inventory report national shoreline study. U. S. Army Corps of Engineers, North Central Division, Detroit, Michigan. 221 p.

This report concerns erosion and the need for protection of the shoreline zone of the United States portion of the Great Lakes. The shoreline zone or shorelands include the land, water and the land beneath the water in close proximity to the Great Lakes shoreline.

Section 10 concerns the State of New York and includes 3 subsections on Lake Ontario - the Lake Ontario West Planning Subarea, the Lake Ontario Central Planning Subarea and the Lake Ontario East Planning Subarea. Each subarea includes a shoreline description, information on erosion and flooding history and solutions to erosion damages.

134. Cronan, D. S. and R. L. Thomas. 1970. Geochemistry of ferromanganese oxide concretion in Lake Ontario. Proceedings, Meeting Geological Society of America, Milwaukee, Wisconsin. p. 529.

A large deposit of ferromanganese oxide sands and scattered manganese nodules extend 210 km. east from Toronto with a maximum width of 20 km. and thickness of 4 cm. The nodule's zinc, nickel, copper and cobalt contents are lower than those found in sea water. Analysis of bottom water associated with the concretions show that manganese, iron, nickel, copper, lead and zinc are highest in concentration indicating the upward diffusion of these elements from buried sediments might be contributing to the concretion formation.

Csandy, G. T. - See: C. R. Murthy, No. 276.

35. Csandy, G. T. 1964. Turbulence and diffusion in the Great Lakes. Great Lakes Research Division, Publication No. 11, Univ. of Michigan. pp. 326-339.

In continuing experimental investigations of turbulent diffusion in the Great Lakes, further data have been collected, particularly on verticle diffusion and diffusion in a current which steadily changes direction ("swinging" current). Also a comparison could be made between diffusion in Lake Huron and Lake Erie, western basin. The low value of verticle diffusity reported before were confirmed, and the extreme influence of thermal stratification on verticle diffusion was demonstrated. Diffusion in a swinging current was found to be considerably more rapid than in a steady one, the effective diffusity (so far as such a concept is useful in that situation) increasing by a factor of 2-5.

36. Csandy, G. T. 1967. Large scale motion in the Great Lakes. Journal of Geophysical Research. 72(16): 4151-4162.

Large scale motion in the Great Lakes consists of three motions.

1. Baroclimic Coastal Jets during summer stratification.
2. Slow counterclockwise rotating internal waves of a period many times the helf-pendulum day.
3. Surface and internal seiches rotating in either direction and having a period of at most several hours (surface modes) or upto within a small fraction of the inertial period (internal modes).

7. Csandy, G. T. 1968a. Simple analytical models of wind driven circulation in the Great Lakes. Proceedings 11th Conference Great Lakes Research. pp. 371-384.

The important dynamical factors in determining large-scale water movements in the Great Lakes sppear to be: (1) wind stress; (2) the constraint of continuity imposed by the shores of a closed basin, (3) Coriolis face - may be assumed constant for a basin as large as the Great Lakes basin.

Summer density stratification and depth variation also exert on controlling influence on the current patterns. Large scale motion features include (1) coastal jets, (2) thermocline movements, (3) current rotation patterns.

138. Csandy, G. T. 1968b. Wind driven circulation in the Great Lakes. Journal of Geophysical Research. 73(8): 2579-2589.

Simplified models of wind-forced motions are considered in a two-layer circular basin "model great lake" introduced in an earlier paper. Under summer conditions, when a thermocline is present, both a uniform, steady wind and a uniform wind varying periodically in time produce a frictionless lake response characterized by strong boundary currents and pronounced thermocline movements in the shore zone. The length scale determining the widths of this shore zone is the "radius of deformation," typically three miles. Observations on Lakes Huron, Michigan and Ontario show such motions to be present near the shores.

139. Csandy, G. T. 1969. The coastal jet project. Department of Mechanical Engineers, Univ. of Waterloo. 18 p.

During the summer of 1969, an extensive series of current and temperature measurements in the coastal zone of Lake Ontario, near Oshawa, Ontario, were conducted. The main scientific objective of the work was to determine whether or how often the theoretically predicted "coastal Jet" phenomenon was in evidence in this area, following some indications during the 1968 season to the effect that such jets were possibly present on certain occasions near Douglas Point, in Lake Huron. A second objective was to further prove the practical value of such observations by means of the relatively inexpensive "flag station technique" which provided useful results during the 1968 season. The Canada Centre for Inland Waters, Burlington, Ontario, again supported the work.

The 1968 observations could be described as essentially a "feasibility study" for two different observation techniques,in the course of which the flag-station technique emerged as superior. The evidence for or against Coastal Jet near Douglas Point remained meanwhile inconclusive, mainly on account of a lack of continuity in the observations. In order to identify a given current pattern as a "coastal jet" it is necessary that it show persistence at least for several inertial periods. The 1969 Oshawa observations were reasonably useful in this regard yielding a fairly complete coverage of the period May 15-July 31, on 48 days of which observations were carried out, giving on most days one cross-section of current and temperature, on some days two. Even though not all sections were complete, the net output represents an acceptably high yield of data in the light of the instrumentation experienced.

Generally speaking, the results obtained show a fascinating wealth of complex phenomena. However, not a single instance of "coastal jets" (= persistent baroclinic currents a few miles wide) could be uncovered, although stratification was pronounced in the second half of the experimental period. As to the flag-station technique, its practical value again became evident, although we also learned of some of its limitations. Instrument (current metering) problems were again fairly serious, but the experience gained will probably prove valuable in later seasons. (Canada Centre for Inland Waters).

140. Csandy, G. T. 1970. On the equilibrium shape of the thermocline in a shore zone. In: Coastal Jet Project, 1970. Canada Centre for Inland Waters. p. 7.

The typical spring thermal regime of Lake Ontario shows a thermocline surface of either a "wedge" or of a "lens" shape persisting in the shore zone for a considerable period. The summer regime is characterized by frequent uptilts or downtilts on the thermocline, with an amplitude comparable in the shore zone to the equilibrium depth of top or bottom layers. These observed facts are explained in terms of a simple theory based on the postulates of geostrophic flow and velocity distributions calculated for a constant-depth shore-zone model exhibit many of the observed characteristics of the spring and summer regimes. (Canada Centre for Inland Waters).

141. Csandy, G. T. 1971. On the equilibrium shape of the thermocline in a shore zone. Unpublished paper presented at the 14th Conference Great Lakes Research, Toronto. April 19-21, 1971. p. 192.

The typical spring thermal regime of (say) Lake Ontario shows a thermocline surface of either a "wedge" shaped or of a "lense" shaped cross section, the warmer water being confined to the shore zone for a considerable period (of order two months). The summer regime is characterized by frequent uptilts and downtilts on the thermocline in the shore zone, or relatively large amplitude, so that the thermocline may come to intersect either the free surface or the bottom of the lake. Once established, such uptilts or downtilts usually persist for at least several days.

The density distribution implied by the above shapes of the thermocline surface cannot be in static equilibrium and the question arises, what kind of dynamic equilibrium enables these distribution to persist for considerable periods. The view has been expressed by Rodgers and others that, at least in the case of the spring regime, the horizontal movement of warm water is checked by mixing at its lakeward edge, but no quantitative theory to this effect has been proposed. An alternative, and as it turns out rather more attractive, explanations is that the observed temperature distribution is in geostrophic valance. In support of this argument the dynamic behaviour of a simple shore zone model is investigated analytically. In a constant depth basin a portion of the water closest to the shore is suddenly heated. Inertial oscillations ensue, and it is also likely that a considerable fraction of the available potential energy appears as kinetic energy of geostrophic motions. If the energy of these is more than half of the available energy, a wedge-shaped equilibrium thermocline develops. A lense-shaped thermocline is also found to be possible and requires somewhat less energy in geostrophic motions.

The theory is based on the conservation of (potential) vorticity, friction being neglected. Without postulating "small" thermocline displacements a simple differential equation is obtained (for either spring or summer regime) the solutions of which exhibit many of the observed thermocline characteristics.

142. Csandy, G. T. and B. Pade. 1971. Coastal current regimes in Lake Ontario. Abstract of paper presented at 14th Conference Great Lakes Research. p. 47.

Originally promped by a desire to search for the theoretically predicted "coastal jets," an extensive series of observations on currents in the coastal zone near Oshawa, in Lake Ontario, have been carried out during 1969 and 1970. A general characteristic of the water movements is the great spatial variability.

Other characteristic features of the observed water movements are: 1. the level of kinetic energy in the currents, and 2. the shape of the associated thermoclinesurface. These appear to go through seasonal changes.

143. Csandy, G. T. and H. G. Pade. 1970. The coastal jet project. Department of Mechanical Engineering, Univ. of Waterloo, Ontario. 20 p.

Current and temperature cross-sections reveals the following features:

1. Spring regime. This is characterized by a thermocline surface ringing the entire lake and isolating the warmer water in a nearshore band, the cross-section of which shows either a "wedge-shaped" or a "lens-shaped" thermocline. Maximum baroclinic currents calculated from the temperature distribution (by the geostrophic approximation) in this regime are of the order of 5 cm/sec, while maximum observed velocities are several times higher (order 20 cm/sec) and are also poorly correlated with the temperature distribution. The current pattern changes from day to day, the fixed current meters showing the occasional presence of inertial oscillations and other unsteady motions. All these motions are, however, mostly confined to narrow spatial regions, much of the surveyed water mass being nearly stagnant most of the time during the spring period.

2. Summer regime. The thermocline surface is now continuous across the lake and often shows an uptilt or a downtilt near the shore. Calculated baraclinic velocities are now higher, of the same order as observed velocities but the two are still poorly correlated. The current pattern still changes from day to day and inertial oscillations are prominent. The total kinetic energy of the motions is appreciably higher than during the spring, although the bottom layers are still nearly stagnant most of the time.

3. Fall regime. The thermocline behaves much as during the summer, although it is located rather deeper. More pronounced and persistent bands of current appear, drifting inward or outward from day to day. The total kinetic energy is very much greater than during spring or summer. Also thermocline uptilts and downtilts are more striking and persistent.

Viewing the Coastal Jet project as a feasibility study for IFYGL work, we may perhaps claim the following:

(a) Observations by means of the flag-station technique are well worth collecting, because no other method so far known provides comparable detail on the fascinating complexity of coastal lake currents. Certainly no practical number of anchored current meters would provide equivalent coverage.

(b) The technique is relatively inexpensive (certainly in comparison with projects requiring larger vessels). A realistic cost estimate is $15,000 per coastal chain per alert period. (We note that this year's contract price did not cover all our expenditures).

In the following, the experimental technique and any difficulties experiences are described briefly, followed by a presentation of the observed data. The data are also illustrated by temperature and current cross-sections, which are largely self-explanatory and demonstrate the points breifly made above. A more detailed analysis of the dynamic factors involved in the observed current distributions may be found in a recent paper of which the abstract is attached, and in a second paper now under preparation. (Canada Centre for Inland Waters).

144. Czapski, U. H., R. Stewart and J. T. Scott. 1970. An estimate of the air-water balance near west Nine Mile Point, Lake Ontario. Proceedings 13th Conference Great Lakes Research. p. 798-810.

A preliminary study of the energy imput into the atmosphere from a small area of the lake surface near Nine Mile Point is reported. The installation of two power stations plus other large heat dissipators (Aluminum Plant), makes this part of the lake an interesting target for energy budget studies. In order to assess the basic unaltered heat fluxes, standard energy budget and aerodynamic techniques are applied using previously published data and field data obtained by the authors in the summer of 1969. Estimates of total latent energy and sensible energy fluxes and the sum of these are obtained from calculations of heat advection and heat storage change in the water, and from dry and wet bulb temperatures, wind speeds and radiation measurements. Assuming that the spread of warm surface waters of thermal effluents from the power station is similar to the known spread of Oswego River effluent as indicated by the data of infrared surveys, estimates of latent and sensible heat flux, in excess of normal from the lake to the atmosphere, are presented as a function of area.

145. Davies, J. A., M. Nunez and P. J. Robinson. 1970. Radiation measurement over Lake Ontario and the determination of emissivity. Abstract of paper presented by McMaster University, Department of Geography. p. 10.

From July to November 1969, a group from McMaster University, in cooperation with the Canada Centre for Inland Waters, carried out a radiation flux study over Lake Ontario. An instrumented tower was installed at the western end of the lake in shallow water (4 m deep) about 400 m from the shore.

The study has four main aims:

1. To define the short-term (hourly) and long-term (daily) variation in the components of the radiation balance at an air-lake interface and their relationships with environmental factors.

2. To examine the feasibility of empirical prediction of these components using relatively simple meteorological predictors.

3. To assess the performance and suitability of available radiation sensors in meteorological studies over lakes.

4. To determine relevant surface parameters, such as albedo and emissivity, which might be useful in analyzing data from remote sensing.

The first report is concerned with the approaches to radiation flux measurement and calculation used in this study. The first part deals with the sensors used, the principles of their operation and their use for specific measurements. In the second part, field methods for determining surface emissivity and temperatures are described and a preliminary discussion of the results are presented.

The second report presents the radiation flux data collected at a tower site in Lake Ontario from July to November 1969. The radiation fluxes are listed for half-hourly periods and as 24-hour totals for each day from July 1 to November 18, 1969.

146. Day, P. C. 1926. Precipitation in the drainage area of the Great Lakes, 1875-1924. Monthly Weather Review. 54(3): 85-106.

The average rainfall for the Great Lakes drainage area from 1875 to 1924 was about 32 inches per year with an increase in precipitation from north to south.

From 1875 to 1885 the precipitation was unusually heavy. From 1917 to 1924 the amount of water reaching the lakes was decreased due to previous extensive logging.

147. Deane, R. E. 1963. Limnological and meteorological observation towers in the Great Lakes. Limnology and Oceanography. 8(1): 9-15.

Six limnological and meteorological single-shaft towers of 4 inch pipe were installed in three of the Great Lakes by the Great Lakes Institute, University of Toronto. The towers were of two types; a shallow water tower for depths of less than 60 ft. where the base of the tower rested directly in the lake bottom, and a deep water tower supported by a bouyancy tank 25 ft. below the lake level. A platform on the towers, situated 8 to 12 ft. above lake level, gave a suitable base of house limnological and meteorological instruments and recorders. The platform and upper tower section were designed for easy removal and reinstallation.

Deck, B. L. - See: R. C. Bubeck, No. 47.

148. DeCooke, B. G. 1967. Control of Great Lakes water levels. U. S. Army Corps of Engineers, Detroit, Michigan. Lake Survey, MP 67-1. 9 p.

The four natural hydrologic factors - precipitation, runoff, groundwater and evaporation - along with the inflow from the lake above are the major factors in determining lake levels. Because of the large natural variations in water supply, it is impracticable to regulate any of the lakes to maintain a constant elevation. This would require enlarging the lake outlets to facilitate a discharge capacity equal to the largest monthly supply to the lake. In some cases, this would double the capacity of the present outlet. Pumps would have to be installed of offset any negative supply when evaporation from the lake surface is greater than the amount of water supplied. The more rational approach is to research regulation of extreme water levels using the same techniques. (Canada Centre for Inland Waters).

149. DeCooke, B. G. 1968a. Great Lakes regulation. Proceedings 11th Conference Great Lakes Research. pp. 627-639.

The paper presents a brief description of the physical characteristics and of the hydraulics and hydrology of the Great Lakes system, along with a summary of regulation studies conducted during the past half century. The technique employed to develop current operational regulation plans on the lakes and the latest international studies for regulation of the entire Great Lakes, and problems of special interest encountered therein are described. Discussion of the derivation of basic data (e.g. levels, flows, supplies, etc.), uniform base of comparison employed in these studies, requirements of regulation, various approaches to regulation, and methods of evaluating results are included. (Canada Center for Inland Waters).

150. DeCooke, B. G. 1968b. Regulation of Great Lakes levels and flows. U. S. Army Corps of Engineers, U. S. Lake Survey, Detroit, Michigan. MP 68-8. 26 p.

This paper presents a brief description of the physical characteristics, as well as hydraulics and hydrology, of the Great Lakes system. Included are tables of average lake levels, outflows, runoff, precipitation and evaporation. The rule and limitation approach to regulation plan development (a plan tailored to the past sequence of water supplies) and the probabilistic and stockastic approach (a plan which gives consideration to the variability of future water supplies) are described and compared. The paper includes a description and samples of regulation plans presently in operation on Lakes Superior and Ontario. The author concludes that it is extremely difficult to improve on the natural regulation of the system. However, from an engineering standpoint regulation of the entire system is feasible, but has not been economically justified to date.

151. DeCooke, B. G. and E. Megerian. 1967. Forcasting the levels of the Great Lakes. U. S. Army Corps of Engineers, U. S. Lake Survey, Detroit, Michigan. MP 67-2. 7 p.

A description is given of the U. S. Lake Survey method of forcasting Great Lakes water levels. The method, in general, consists of determining a level for each month of a 6-month forcast period on each of the Great Lakes by routing a predicted volume of water (Net Basin Supply) to each of the Great Lakes Basins. The technique employed in prediction of the volume of the water consists of using multiple linear regressions based on U. S. Weather Bureau precipitation and temperature data as precitors for the first month and trend predictors for the second through the sixth month. This technique results in forcasting of lake levels on the average from 15 to 40% closer to the recorded lake levels in comparison with the technique that utilizes the long term average volume of water as the basis of projection.

152. Denison, N. 1898. Periodic fluctuations of the Great Lakes. Monthly Weather Review. 26: 261-262.

Two self recording depth gauges were used to determine lake fluctuations in Toronto region of Lake Ontario. Lake fluctuations were measured and two types identified:

1. larger undulations of about 20 minutes.
2. smaller undulations of about 10 minutes.

It was stated that the lake level never reaches a stationary level.

153. Denison, P. J. and F. C. Elder. 1970. Thermal inputs to the Great Lakes, 1968-2000. Proceedings 13th Conference Great Lakes Research. pp. 811-828.

A survey of expected man-made thermal imputs to the Great Lakes system from electric generating plants, steel mills and municipal waste treatment plants for the period 1968-2000 has been completed. The present thermal imput of 9.98×10^{10} Btus. per hour of the total lake system is expected to rise more than 11 times to 114×10^{10} Btu. per hour by the year 2000. As an indication of the magnitude of this projected thermal input, the contribution to Lake Ontario in 2000 A.D. will amount to 6% of the total annual natural heat storage in the Lake.

154. Dewey, C. 1838. Temperature of Lake Ontario. American Journal of Science. 33: 403-405.

Lake Ontario fails to freeze in the winter due to its great water volume (depth and surface volume). In late winter, some ice forms but is quickly broken up by strong winds. The shoreline area is cooler in the winter months and warmer in the summer. The great depth in the lakes center basins resist thermal change.

155. Dewey, C. 1839a. On the polished limestone of Rochester. American Journal of Science and Arts. 37: 240.

The occurrence of several areas of polished limestone in the Rochester area indicate a strong frictional agent working or running over these large rocks for long periods of time. Several hypothesis are presented but no conclusions are drawn.

156. Dewey, C. 1839b. On the temperature of Lake Ontario. American Journal of Science and Arts. 37: 242-243.

A repetition and varification of previous work on a surface temperature study of Lake Ontario from the Genesee River to Coburg. The effect of water depth in the central basin on the surface temperature of the lake is implied. The center lake area is cooler in summer and warmer in winter due to the large water masses thermal resistance.

157. Dewey, C. 1843. Straie and furrows of the rocks of western New York. American Journal of Science and Arts. 44: 146-150.

Article reveals the location of areas in Western New York where large furrows and straie appear in large rocks. These are believed to be produced by glaciers and icebergs along with strong water currents. The strong currents would also be responsible for the movement of many large boulders.

158. Dewey, C. 1859. The varying level of Lake Ontario. American Journal of Science (2nd series). 27: 398-399.

A general discussion of the degree, causes and effects of lake variation is presented. Causes can be inflow-outflow volume ratios, precipitation-evaporation ratios and atmospheric pressure. Lake level data are presented and discussed.

Digman, Ralph E. - See: F. K. Mack, No. 257.

Diment, W. H. - See: R. C. Bubeck, No. 47.

[illegible] Dohler, G. C. and R. J. D. MacKenzie. 1969. A discussion on the interpretation of high and low water datum planes in the Great Lakes. Proceedings 12th Conference Great Lakes Research. pp. 415-550.

There is a growing and continuing requirement for more precise definitions of the various levels of the Great Lakes. Every sector of the Great Lakes Basin Community is affected sooner or later by the lake levels. The purposes of high and low water datum are examined and defined, and the criteria which could meet these requirements are established. All available water level data are analyzed and techniques developed for the selection of appropriate datum planes.

[illegible] [illegible], [illegible] H. 1940. Water resources of the Clyde and Sodus Bay quadrangles. New York State Museum Bulletin No. 320. 159-171 p.

Included in this article is a discussion of the surface waters of the two quadrangles which includes Lake Ontario and its tributaries.

[illegible] [illegible], [illegible] and G. D. Hobson. 1968. Transit sonar measurements in Lake Ontario off the mouth of the Niagara River. Proceedings 11th Conference Great Lakes Research. pp. 179-187.

Records obtained from a Kelvin Hughes Transit Sonar instrument have been spliced together and a comparison made between amplitude of signal and bottom samples to identify bottom materials. Supplementary data from hydrographic charts enables a fairly comprehensive interpretation to be made.

There is virtually no penetration into the sediments by the sound beam from the sonar, penetration being about [illegible] into the very recently deposited sediment. The [illegible] intensity of the recorded beam is dependent [illegible] bottom topography and the composition of the [illegible] of the water bottom interface.

One profile was surveyed along about five miles of the Niagara River above Niagara-on-the-Lake. This record shows the strong reflection from the east bank of the river, as well as the strong indication of a mud and sand bottom. [illegible] prominent ridges are revealed which, from [illegible] may be 8-10 ft. high. Twenty other [illegible] surveyed in Lake Ontario off the mouth of the Niagara River. These records are shown with an interpretation of the bottom materials and a correlation of data from coring stations and hydrographic charts.

Dragert, H. - See: T. L. Richards, No. 313.

162. Drake, R. L., D. V. Anderson and C. P. Peterson. 1971. Explanation of and preliminary results from a mesoscale model of Lake Ontario. Unpublished paper presented at the 14th Conference Great Lakes Research, Toronto, April 19-21, 1971. pp. 177-178.

A mesoscale model for the study of lake-effect storms over Lake Ontario is being constructed and tested. The model being employed is a modification of the Lavoie Lake storm model. The principal quantities which are obtained from this model are the horizontal wind components, potential temperature and humidity in an adiabatic layer, and the height of the inversion layer. Auxiliary quantities are the average vertical velocity and the amount of rain or snow falling to the ground.

163. Drummond, A. T. 1889. Some Lake Ontario temperatures. Nature. 40: 416.

The surface temperatures of Lake Ontario vary in June on an average of 1 to 3°C. The thermal gradients, as depth increase vary to a much greater extent. The air-water temperature imbalance produces noticable climatological effects in fall and spring, but not summer and winter due to the lesser degree of variance between temperatures at this time.

164. Dunn, B. 1967 Maximum known stages and discharges of New York streams through 1967. U. S.Geological Survey Bulletin 67. 57 p.

This report represents a compilation of all known maximum stages and discharges in the files of the Geological Survey, including a limited amount of data furnished by other Federal, State and Private Organizations. The data are tabulated under the heading of the major river or lake basin in which the stream is located.

Dutka, B. J. - See: A. S. Menon, No. 269.

Dutka, B. J. - See: J. N. Vanderpost, No. 421.

Eadie, W. J. - See: G. E. McVehil, No. 266.

Elder, F. C. - See: P. J. Denison, No. 153.

165. Elder, F. C. and R. K. Lane. 1970. Some evidence of meteorological related characteristics of lake surface temperature structure. 13th Conference Great Lakes Research. pp. 347-359.

The surface temperature structure of western Lake Ontario was mapped using an infrared scanner and an infrared thermometer on four days during a six-day period in May 1969. Spatial resolution of the infrared scanner gave extreme detail in the surface temperature structure and the repetition on closely spaced days allowed determination of rates of change and persistence of the surface temperature features. Features such as the Niagara River plume were persistent throughout the six-day period. However, very detailed patterns showing evidence of banded, cellular and rotational structure were observed. It is shown that these features are associated with existence of a convectively unstable layer near the surface caused by surface heating of water at less than the maximum density temperature. These surface features are shown to be present only in the near absence of mechanical mixing and are, therefore, related to the prevailing meteorological conditions. (Key words: air-water interaction; instruments and techniques; Lake Ontario). (Canada Centre for Inland Waters).

Eryuzlu, N. E. - See: R. L. Pentland, No. 296.

166. Fairchild, H. L. 1893. The geological history of Rochester, New York. Proceedings Rochester Academy of Science. 2: 215-223.

Using a 3000 ft. core sample drilled in Rochester, an analysis is made of the geological history of the area. By correlating certain rock strata by location and composition, with previously known information on environmental characteristics producing the rock strata, a rather detailed picture of the history is produced. The author follows through several areas of glacial deposits, lake and stream deposits with reference to duration and depth.

167. Fairchild, H. L. 1928. Geologic story of the Genesee Valley and Western New York. Scrantom's Company, Rochester, New York. 216 p.

Geological history believed to be responsible for the formation of Rochester Canyon, Portage and Mt. Morris Canyons. Includes glacial periods and various lake and river stages involved.

168. Fairchild, H. L. 1932. New York moraines. Geological Survey of American Bulletin. 43: 627-662.

This article contains data of the following subjects: moraine descriptions and belts, the Susquehanna Valley kames, the Escarpment, Valley Heads Moraine, the Hamburg-Batavia-Victor Moraine, the deglaciation interval, the kame areas-Waterloo-Auburn Moraine-Second Lake Warren, the Albion-Rochester Moraine, the Oswego Moraine, the conflict of Lake and glacier, valley lobations and ice front reentrants movement of the Ontario Ice Body, Syracuse district-drainage control, Mohawk Valley lobations, Catskills and Adirondacks drift and mountain glaciers.

Fenlon, M. - See: D. R. Landsberg, No. 243.

Fenlon, M. - See: J. T. Scott, No. 343.

Fisher, D. W. - See: J. G. Broughton, No. 39.

169. Fisher, Donald W. 1960. Correlation of the Silurian rocks in New York State. New York State Museum and Science Service Geological Survey, Map and Chart Series No. 1. 1 sheet.

Contains a large map and accompanying tables of the Silurian rocks in New York State. The various geological eras are discussed along with geology, stratigraphy, evolution, erosion and topography.

170. Fisher, Donald W. 1962a. Correlation of the Cambrian rocks in New York State. New York State Museum and Science Service Geological Survey, Map and Chart Series No. 2. 1 sheet.

Contains a large map and accompanying tables of the Cambrian rocks in New York State. The various geological eras are discussed along with geology, stratigraphy, evolution, erosion and topography.

171. Fisher, Donald W. 1962b. Correlation of the Ordovician rocks in New York State. New York State Museum and Science Service Geological Survey, Map and Chart No. 3. 1 sheet.

A large Geological map and discussion involving the Ordovician rocks of New York State, their subdivisions and correlations and characteristics of each.

172. Fisher, Donald W., Y. W. Isachsen, L. V. Rickard, J. G. Broughton and T. W. Offield. 1962. The geology of New York State. New York State Museum Map and Chart Series No. 5. 10 sheets.

Large topographical, geological maps of New York State. Counties included along Lake Ontario and the Niagara River include: Erie, Niagara, Orleans, Monroe, Wayne, Oswego, Je-ferson and St. Lawrence.

173. Forrester, G. C. 1928. The falls of Niagara. D. Van Nostrand Company, Inc., New York City, New York. 154 p.

Evolutionary of geological information on the falls of Niagara, the Niagara River, the shorelines along the river, and the Niagara Escarpment. Includes extensive data on glaciation, erosion, rivers and changes in the general geography of the area.

Fortin, J. P. - See: T. L. Richards, No. 314.

174. Fricbergs, K. S. 1965. Beach stabilization in the Toronto area. Unpublished thesis for registration in the Assoc. of Professional Engineers of Ontario. 110 p.

Ever since the first settlers increased the growth of the Toronto peninsula by clearing the Scarborough Bluffs, the local beaches have undergone profound man-made changes. Construction of groynes, dredging for landfill or harbor entrances, power plant discharges and land reclamation, as well as ability to control the lake levels have been the main agencies in shoreline movement.

A wave rose reveals that the prevailing south-westerly winds are almost incapable of rising ten foot waves, while the easterly storms may produce waves of the 12-14 foot class.

The summer months from May to October are found to be relatively calm. In winter months there are storms capable of reducing the man-made beaches of the order of a hundred feet in less than two days. Hence, any landfill program in the open lake initiated for protection of unsuitable material (garbage) should have a clean fill-to-garbage ratio of at least three to one.

175. Fricbergs, K. S. 1970. Erosion control in the Toronto region. Proceedings 13th Conference Great Lakes Research. pp. 751-755.

The Toronto Island, a recurved sandspit that protects the Toronto Harbour, has been formed by littoral drift derived from the eroding Scarborough Bluffs nearby. Increasing stability of the Bluffs and dredging for fill and harbour entrances have combined to starve the island markedly. A number of protective measures appear to have given only temporary relief and/or compounded the problem elsewhere.

Availability of construction excavation material from the city central section has enabled the Harbour Commissioners to reclaim economically for the growing harbour 90.6 hectares from the lake in 14 years. Now a breakwater, built of the same material along the 10 m contour is three km long and shelters the developing outer harbour.

Slope adjustment goes on for several years and may require renurishment. For equal exposure, steepness depends on median size and gradation. The lateral movement of the material is constricted by protruding points built of larger sizes.

176. Gannon, J. E. and A. M. Beeton. 1969. Studies on the effects of dredged materials from selected Great Lakes Horbours on plankton and benthos. Center for Great Lakes Studies, Univ. of Wisconsin, Milwaukee. Special Report No. 8. 82 p.

Sediment from the harbors of Buffalo, New York; Calumet, Illinois; Cleveland, Ohio; Great Sodus Bay, New York; Green Bay, Wisconsin; Indiana Harbor, Indiana; Milwaukee, Wisconsin, Rouge River (Detroit), Michigan; and Toledo, Ohio were analyzed for COD, NH_3-N_2, organic N_2, PO_4-P and volatile solids. Gross observations and particle size analysis data are also tabulated.

177. Gibbes, L. R. 1857. Remarks on Niagara Falls. Proceedings of the American Association Advancement of Science, 10th Meeting, Albany, New York. pp. 69-78.

The evolution of Niagara Falls has taken place due to water erosion at a very slow pace from the Bluffs at Lewiston to its present site. The falls must have developed into two falls upon approaching Goat Island with the recent erosion of the Canadian Falls, nearly three times as fast as the American Falls.

Giese, G. L. - See: W. G. Weist, No. 431.

178. Gilbert, B. K. and J. C. Kammerer. 1965. Summary of water resources records at principal measurement sites in the Genesee River basin through 1963. U. S. Department Interior, Geological Survey, Bulletin 56. 55 p.

This report is a tabular summary of more than half a century of water measurements (mainly streamflow) in the Genesee River basin by the U. S. Geological Survey, usually in cooperation with State and other Federal agencies. The range in streamflow is from less than 1 cfs (cubic feet per second) during dry-weather periods on five tributaries measured, to a flood flow on the Genesee River itself of more than 55,000 cfs, near Mt. Morris on May 17, 1916. The average flow of the Genesee River at Rochester is 2,738 cfs, equal to a basin-wide runoff of 1.1 cfs per square mile, or 15 inches of water annually.

Ground water levels measured in three wells for more than ten years, show no long-term decline of the water table. Generally, water levels are highest in the spring and lowest in the late summer or fall.

179. Gilbert, G. K. 1899. Sculpture of the Niagara limestone. Bulletin Geological Society of America. 10: 122-125.

A discussion of observations and samples taken of the limestone in the area of Western New York and adjacent Ontario. The location, formation, distribution, characteristics and effects of these formations are discussed.

180. Gilbert, G. K. 1907. Rate of recession of Niagara Falls. U. S. Department Interior, Geological Survey, Bulletin No. 306. 31 p.

Readings taken in 1827, 1842, 1875, 1886, 1890 and 1905 indicate an average recession for the Horseshoe Falls of 5 ft./year while that of the American Falls is 3 inches/year. A rather detailed description of survey techniques, falls features and geographic formation accompanies this paper.

181. Gillette, Tracy. 1940. Geology of the Clyde and Sodus Bay quadrangles, New York. New York State Museum Bulletin No. 320. p. 1-158.

The Clyde and Sodus quadrangles are located in west central New York and have Lake Ontario as their northern boundary with their southern limit approximately one mile south of the Wayne County line. A detailed stratigraphic relationship is given followed by a discussion of the historical, glacial and economic geology of the two quadrangles.

182. Gillette, Tracy. 1947. The Clinton of western and central New York. New York State Museum Bulletin No. 341. 191 p.

Except for a limited region in the vicinity of Clinton, N. Y., where the strata outcrop in the highland to the south of the Mohawk River, the Clinton underlies the plains to the south of Lake Ontario and the low areas surrounding Oneida Lake. Included in the report is a discussion of the general characteristics of the Clinton group, detailed stratigraphic and paleontologic relations, historical geology, description of sections from the Niagara gorge through Willowvale and a description of diamond drill cores.

183. Godin, G. 1971. Hydrodynamical studies on the St. Lawrence River. Canadian Department of Energy, Mines and Resources, Ottawa. No. 18. 116 p.

Use has been made of the fundamental concepts of hydrodynamics to study the steady and tidal flows in the St. Lawrence River.

The equations of hydrodynamics take on a very simple form for steady flow as it is the case between Montreal and Trois Rivers. The definition and the meaning of the quantities they relate such as the mean depth D, the inclination of the river bed I, of the surface Sx, have been carefully reviewed. The mean inclination of the surface of the river Sx, which is always positive, is found to be remarkably constant from year to year in spite of the variations occurring in the discharge. Using this fact, it is possible to reduce a value of the Chezy coefficient between Montreal and Sorel.

A plot of the mean level for all the stations located between King Edward Pier in Montreal and Points au Pere shows the mean downwards slope of the surface of the river when undisturbed by the tide. The monthly fluctuations of this mean level decrease downstream since the capacity of the river bed increases in this direction. The mean flow is found to be subcritical and, therefore, cannot impede the propagation of the tide upstream.

The propagation of the tide may be understood using the time dependent form of the Equations of Hydrodynamics. An elementary solution of these equations shows that under the influence of linearized friction, the tide is damped exponentially and is retarded in its progress upstream. The actual occurrence of quadratic friction in the equations implies the creation of fast and slow shallow water constituents along the river; the speed of progress of the tide upstream is ascertained from observations. The use of the current observations in conjunction with the time dependent equations of motion allows the deduction of the value of the Chezy coefficient which prevails in the part of the river which extends between Trois-Rivieriers and Quebec.

The spectral analysis of the water levels recorded by the water level gauges reveals that the low frequency band contains oscillation of 15, 9, 7 and 5 days which may be traced to the interaction of the tidal constituents. The change in phase and amplitude of the major tidal constituents deduced from the same analysis has been plotted and supplies the material which has to be reproduced in a mathematical model of the river. The current observations carried out by G. C. Dohler and the Ship Channel Division have been analyzed as well, whenever possible. The suggestion by W. D. Forrester that the average one dimensional currents in a river could be indirectly deduced from the readings on the tide gauges and the equation of continuity rather than by direct observations has been confirmed by our analyses. (Univ. of Toronto, Great Lakes Institute).

184. Grabau, A. W. 1895. The preglacial channel of the Genesee River. Proceedings Boston Society of Natural History. 26: 359-369.

This paper attempts to show the existence of two northward flowing preglacial rivers in Western New York, parallel to the Seneca, Cayuga and other rivers whose valleys are now occupied by the Finger Lakes. These two rivers are the Caneseraga and Genesee. Drift deposits forced the Genesee to leave its ancient course at Portageville and to cut across the intervening plateau to Mt. Morris, from which point it occupied the channel of the Caneseraga. Further glacial action and deposits of materials altered the river to its present course.

185. Grabau, A. W. 1901. Guide to the geology and paleontology of Niagara Falls and vicinity. New York State Museum Bulletin No. 45. [illegible] 286.

A general discussion of geography, geology, stratigraphy and fossils of the Niagara Falls region. Included is a bibliography of works completed on the geology of Niagara Falls. (Schoellkopf Museum, Niagara Falls, N. Y.).

186. Great Lakes Basin Hydrolic and Hydrologic Data Coordinating Committee. 1958. Lake Ontario outflows. Committee report. 100 p.

Because of the insignificant amount of water contributed to the St. Lawrence River by sources other than Lake Ontario, the flow volume of the river is an accurate measure of lake outflow volume. Flow gauges are measured at these sites: Rapids Flat (Locks [illegible]), Galop Rapids (Lochs # 27), and long Sault Rapids (Locks [illegible]). The effects of lake and river ice is discussed along with charts of mean monthly and daily flows.

187. Great Lakes Basic Hydraulic and Hydrologic Data Coordinating Committee. 1962. History of water level gages, Lake Ontario and the International section of the St. Lawrence River. Committee report. [illegible] p.

Location, Operating Agency, data collection, station maintenance, history and period of operation from existing stations on the shore of Lake Ontario and the St. Lawrence River in the following locations:

Toronto
Cobourg
Brighton
Kingston
Tribbetts Point
Sockets Harbor
Port Ontario
Oswego
Little Sodus Bay
Charlotte
Oak Orchard
Sodus Bay
Olcott
Wilson
Fort Niagara
Port Weller

188. Great Lakes Institute. 1964. Data record [illegible] surveys Part I, Lake Ontario and Lake Erie. Great Lakes Institute, Univ. of Toronto. PR 18. 67 p.

Tabulated data for the surface waters of Lake Ontario are presented on: transparency, temperature, conductivity. Surface weather observations are also tabulated and these include: wind direction and speed, visibility, [illegible] cover, opacity, air temperature and dew point. Data on wave height, direction, period and length are given.

Descriptive information is also included in the tabulations which give date, time, depth and location of sampling.

Data obtained during synoptic weather observations is also tabulated and includes wind speed and direction, mean sea-level pressure, temperature (air, surface, dewpoint, wet bulb), cloud amount, type and height, wave direction, period and height and swell period and height. Solar radiation data and bathythermograph data are also given.

189. Great Lakes Institute. 1965. Great Lakes Institute data record - 1963, surveys Part I - Lake Ontario, Lake Erie and Lake St. Clair. Great Lakes Institute, Univ. of Toronto. Report PR 23 193 p.

Data collected by the Great Lakes Institute (on the CCGS *Porte Dauphine*) for the year 1963 is summarized in this report. The Lake Ontario Survey was from stations extending from Toronto southeast to the center of the lake. Data was collected on: wind, atmospheric pressure, humidity, temperature (water and air), clouds, waves, swells, radiation, water color and turbidity.

190. Great Lakes Institute. 1969. Proceedings - a conference for the Users of the Great Lakes. Sponsored by the Ontario Water Resources Commission, Great Lakes Institute, Univ. of Toronto. 131 p.

A series of discussions by representatives of various governmental agencies to clarify objectives, techniques, and conclusions. The first discussion session dealt with water supply and a general debate on related topics.

191. Great Lakes Institute. 1971. Great Lakes Institute data record-surveys of 1964-Lake Ontario, Lake Erie, Lake St. Clair, Lake Huron, Georgian Bay and Lake Superior. Great Lakes Institute, Univ. of Toronto. Report PR 42. 238 p.

Data collected by the Great Lakes Institute (in the CCGS *Porte Dauphine*) for the year 1964 is summarized in this report. The Lake Ontario survey was from stations extending throughout the lake. Data was collected on: wind, atmospheric pressure, humidity, temperature (water and air), clouds, waves, swells, radiation, water color and turbidity.

192. Greeson, P. E., G. W. Williams and F. L. Robison. 1969. Characteristics of New York lakes - Part 1 - Gazetteer of lakes, ponds and reservoirs. U. S. Geological Survey, Albany, New York. Investigation RI-4. 28 p.

A method is established for computer storage of data on New York lakes, ponds and reservoirs. Locations of which are indicated on a map of New York State and general drainage basin information is presented.

193. Gridwald, R. E. 1951. The ground water resources of Wayne County, New York. New York State Conservation Department, Bulletin GW-29. 30 p.

The area of Wayne County comprises two topographic divisions - a drumlin region and a lake plain. The climate is temperate and the mean annual air temperature is 47°F. The average annual precipitation is 36 inches. The geology of bedrock and the relationship of properties and structures of the bedrock to the ground water supply is discussed.

Grunsky, C. E. - See: R. E. Horton, No. 212.

194. Gunwaldsen, R. W., B. Brodfield and G. E. Hecker. 1970. Current and temperature surveys in Lake Ontario for the James A. Fitzpatrick nuclear power plant. Proceedings 13th Conference Great Lakes Research. pp. 914-926.

Measurements of lake currents and temperatures were made offshore from Nine Mile Point to approximately seven miles east of Oswego, New York. Two underwater towers, installed an approximately 7-13 m of water, were equipped with self contained instruments at various depths from May to October 1969. Two current pattern surveys were conducted by releasing approximately 50 drogues which were traced by aerial photography over a one square mile area adjacent to the shore. Air borne infrared radiometry was used to measure surface temperatures during the current pattern survey. Current data indicate the frequency of various speeds, directions and durations. Temperature records show the gradual seasonal change, as well as the relatively rapid variations caused by oscillations in the thermocline.

195. Hachey, H. B. 1952. Verticle temperature distribution in the Great Lakes. Fisheries Research Board of Canada. 9: 325-328.

This paper presents data and conclusions of a study of thermal distribution in Western Lake Ontario. The thermocline was found as deep as fifty feet and a temperature change witbin of up to twenty-six degrees Fahrenheit. The variance of surface layer thickness is also discussed.

196. Haefeli, C. J. 1970. Regional groundwater flow between Lake Simcoe and Lake Ontario. Department of Energy, Mines and Resources, Inland Waters Branch. Technical Bulletin No. 23. 42 p.

The configuration of the water table corresponds generally with the topography. Prezometric, hydrogeochemical and mathematical analysis demonstrate the non-existance of major seepage from Lake Simcoe into Lake Ontario basin. The groundwater divide coincides approximately with the basin boundary in the quarternary deposits, as well as in the different underlying bedrock formations. Geological and hydrological data are discussed in depth.

197. Hall, J. 1843. Geology of New York. Survey of the Fourth Geological District. Carroll and Cook Printers, Albany, New York. 681 p.

Geological survey of materials and land formations of Western New York State. Includes descriptions of Lake Ontario shore processes and elevation of various land forms. A very detailed description of properties and structures.

198. Hamblin, P. F. 1968. The variation of the water level in the western end of Lake Ontario. Proceedings 11th Conference Great Lakes Research. pp. 385-397.

The variation of the water level in the western end of Lake Ontario is investigated by a number of analyses of hourly level water data. Water level gauges located at Toronto, Hamilton, and Port Weller provided data of two four month periods; one extending from June to September, the other from December to March. Attention is given to the detection of the frequencies of the uninodal and binodal longitudnal surface seiches, to the frequency of the semidiurnal tide and to the frequencies of the water level variation associated with disturbances of the atmospheric wind. In order to examine water level readings for the presence of rotation of the cotidal lines about the western end of Lake Ontario. The geometric configuration of the plane passing through the surface heights at each of the three gauge stations is computed. Periodic changes in the orientation of this plane and in the water level readings themselves are examined by spectral and cross spectral analysis. Several episodes of amphidromic motion are detectable. In addition, theory of free surface oscillation is discussed and some details of the analysis are described.

199. Hamblin, P. F. 1971. An investigation of horizontal diffusion in Lake Ontario. Abstract of paper presented at 14th Conference Great Lakes Research. pp. 162-163.

Predicting the response of the lakewide water quality to changing levels of concentration of imputs depend on a number of biological, chemical and physical processes. Physical factors of importance are lakewide circulation and large scale diffusion. Rhodamine B dye was pumped in a large quantity onto the surface and allowed to diffuse. After 29 hours the resulting plume covered a large horizontal area which was analyzed for diffusion patterns.

200. Hamblin, P. F. and G. K. Rodgers. 1967. The currents in the Toronto region of Lake Ontario. Great Lakes Institute, Univ. of Toronto. PF 29. 134 p.

Beginning in June 1966, the Great Lakes Institute embarked on a programme of observation of water movement, winds and water temperatures in a region of Lake Ontario adjacent to Metropolitan Toronto. The programme was undertaken in pursuance of two scientific objectives: first, the description of the climate of the current in the Toronto area and second, to draw conclusions about the behavior of currents as related to determining variables. Such as understanding of the relation of currents to the causative forces would not only be an important advance of the physical understanding of the Great Lakes but would serve as a basis for the forecasting of currents in the nearshore areas. This, in turn, can be useful to those designing the operating water processing installations. Initially, various techniques of current measurement used in the past and present were examined critically with a view to evaluation of their relative effectiveness in description of the flow close to shore.

These studies were made possible through the generous support of the Ontario Water Resources Commission.

Though advanced studies of the data collected in the field season of 1966 continue, this presentation is the full reporting of the observation taken in the field up to March 31, 1967.

The region of interest extends for some 20 km along the northern shoreline of Lake Ontario from Humber Bay on the west to Scarborough Bluffs on the east and offshore for approximately 5 km. Within this general area, a key location for the most extensive series of observations was chosen about 1 km directly offshore from Balmy Beach, Toronto.

201. Hartnagel, C. A. 1969. Geologic map of the Rochester and Ontario Beach quadrangles. New York State Museum. Bulletin 114. Paleontology 17. 32 p.

The quadrangles are discussed with reference to geology, geological formation, stratigraphy and erosion. Many of the beach and shore areas are discussed as to erosion unusual formations, properties and structures and occurrences.

202. Hayes, G. E. 1839. Remarks on the geology and topography of Western New York. American Journal of Science. 25: 87-105.

A general description from observation of the geology and topography of Western New York. Much data is presented on the topography and geology of the southern shore of Lake Ontario. The author describes the shorelines as consisting of a 6 mile wide band of red sandstone ending in a large limestone terrace at varying distances from the lake.

203. Heath, R. C. 1964. Ground water in New York. New York State Conservation Department, Water Resources Commission. U. S. Geological Survey. Bulletin GW-51. 1 sheet.

Ground water data for New York State is presented with data on precipitation, runoff, streams and geology. A large map of the ground water characteristics is accompanied by written explanations.

Hecker, G. E. - See: R. W. Gunwaldsen, No. 194.

204. Herdendorf, C. E. 1970. Lake Erie physical limnology cruise, midsummer 1967. Report of Investigations No. 79, State of Ohio Department of Natural Resources, Division of Geological Survey, Columbus. 77 p.

Tabulated data for the surface water of the Niagara River at Buffalo are presented on: water temperature, current velocity and direction, conductivity, pH, color and turbidity. The location of the sampling station, time and date of sampling, and depth of sample are also given. Surface observations are made which include: wind direction and velocity and wave direction and height.

205. Heubusch, Carol A. Undated. How the great glaciers changed the Niagara Frontier. Buffalo Museum of Science, Hobbies. 38(3): 10.

A general discussion of the topography of the Niagara frontier before the glacier invasion is given. This is followed by a discussion of the changes brought about by the glaciers. Such as the land features formed by deposition, the origin of the Finger Lakes and the Great Lakes, the formation of Niagara Falls and the rock particles making up the glacial drift.

206. Hiney, R. A. 1969. Optimum regulation of the levels of the Great Lakes. M. S. thesis, State University of New York at Buffalo. 84 p.

In 1964 the governments of Canada and the United States authorized a massive international study to determine what measures could be taken to further regulate the levels of the Great Lakes. A regulation subcommittee is currently devising and testing regulation plans in an endeavor to find one plan that will best serve all Great Lakes interests.

This thesis investigates the feasibility of using a dynamic programming algorithm to find this optimum regulation plan given objective functions relating dollar losses of each interest to monthly mean lake levels and outflows. The optimum plan will be that which minimizes these objective functions for a given set of inflows and flow constraints.

Inflow sequences will consist of both the recorded adjusted net basin supplies and 390 years of artificial monthly net basin supplies simulated to preserve as nearly as possible the serial and interlake correlations observed during the period of record.

The regulation rules will be derived from a multiple regression analysis. The resulting empherical formulas will relate the monthly regulated outflow from each lake to significant hydrological parameters such as antecedent inflows and current lake levels. Comparison of losses incurred with the derived plan to those which would occur for the same inflows and existing conditions will indicate the benefits attributable to the plan.

Hobson, G. D. - See: R. J. Donato, No. 161.

207. Hobson, George D. and J. Terasmae. 1968. Pleistocene geology of the buried St. David's Gorge, Niagara Falls, Ontario. Geophysical and Palynological Studies. 11th Conference Great Lakes Research (Abstract). p. 20.

A startigraphic drilling project was undertaken in the 1965-66 winter season, following geophysical studies designed to determine the location, width and depth of the buried ancient Niagara River Valley leading from the "whirlpool" of the present river to St. David's and thence north toward Lake Ontario. Depths below the surface in excess of 150 ft. have been calculated resulting in a channel approximately one mile wide incised into bedrock to a depth of about 80 ft. Cold climatic conditions are inferred from the palynological evidence and a late mid-Wisconsin age has been assigned to the non glacial beds. The St. David's gorge was cut either during the last interglacial (Sangamon) interval, or earlier.

208. Hobson, George D. and J. Terasmae. 1969. Pleistocene geology of the buried St. David's Gorge, Niagara Falls, Ontario: Geophysical and Palynological Studies. Department of Energy, Mines and Resources. Geological Survey of Canada. Paper 68-67. 16 p.

A stratigraphic drilling project was undertaken in the 1965-66 winter season, following geophysical studies designed to determine the location, width and depth of the buried ancient Niagara River valley leading from the "whirlpool" of the present river to St. Davids and thence north towards Lake Ontario. J. W. W. Spencer in 1905 delineated a buried channel in the bedrock from the "whirlpool" to St. Davids.

The geophysical studies consisted of a refraction seismic survey utilizing a portable hammer seismograph and delineated a bedrock depression extending northwestward from the Whirlpool Rapids to the St. David's Gorge and northward below the Niagara escarpment to a point east of Virgil where the channel appears to bifurcate with one branch extending northward to Lake Ontario and the other northeasterly to the Niagara River. Depths below surface in excess of 150 feet have been calculated resulting in a channel approximately one mile wide incised into bedrock to a depth of about 80 feet. Subsequent drilling has verified the seismic picture.

No fossiliferous beds were found in the boreholes between St. Davids and Lake Ontario below the Niagara escarpment. In the St. Davids Gorge, however, borehole 5 revealed the presence of pollen and plant macrofossils in silt, clay and sand at a depth of 106-183 feet from surface. These beds are both overlain and underlain by glacial deposits. Wood from the 150-foot level was dated at 22,800±450 years before present (GSC-816). Pollen assemblages in samples taken from the 80-foot sequence of nonglacial beds were dominated by spruce (*Picea*) and pine (*Pinus banksiana*) with small numbers of fir (*Abies*), birch (*Betula*) and several different types of non-tree pollen (including f. ex. *Artemisia*, *Ambrosia* and *Chenopodiaceae*). Spores and ferns, fungi and *Selaginella* were found in some samples and pre-Pleistocene spores were present frequently. Moss leaves, fragments of bark, leaf cuticle and conifer needles, and twigs indicate presence of local vegetation. Cold climatic conditions are inferred from the palynological evidence and a late mid-Wisconsin age has been assigned to the nonglacial beds. The St. Davids Gorge was cut either during the last interglacial (Sangamon) interval, or earlier.

209. Holley, G. W. 1874. The proximate future of Niagara, review of Prof. Tyndall's lecture thereon. Proceedings American Association Advancement of Science, 32nd Meeting. pp. 147-163.

A general discussion is presented on the rate of erosion of Niagara Falls with reference to previous estimates of falls positions in the future. Many sketches are reviewed to ascertain erosion rate. The author arrives at estimates much larger than Professor Tyndall and predicts the falls will be at the upstream point of Goat Island before 5000 years at an erosion rate of about 12,000 years/mile.

210. Holleyman, J. B. 1966. Some results of the program conducted by Great Lakes - Illinois river basins project on the Great Lakes. Proceedings 9th Conference Great Lakes Research, Great Lakes Research Division, Univ. of Michigan. Publication 15. pp. 323-331.

A study of water pollution of the Great Lakes is being conducted by the Federal Water Pollution Control Administration. To gain an understanding of the motion of pollutants in the lakes, networks consisting of instrumentation to record lake current and surface wind data were established in Lakes Michigan, Erie and Ontario. These networks and instrumentation are described, tabulations of available data are presented and the collection and reduction of data are briefly discussed.

Winds recorded by the network and winds observed aboard ships navigating the Great Lakes are compared with geostrophic winds determined from synoptic weather maps. The results are presented in terms of ratios of actual wind speeds to geostropic wind speeds and deviation in direction of actual winds from the direction of geostrophic winds.

Holroyd, E. W. - See: J. E. Jiusto, No. 223.

Horton, A. H. - See: H. K. Barrows, No. 26.

211. Horton, J. H. 1968. Shorecliff erosion on the north shore of Lake Ontario at Scarborough, Ontario. 11th Conference Great Lakes Research (Abstract). pp. 74-75.

Field studies of erosional processes acting on complex unconsolidated glacial and interglacial shorecliff materials were carried out at Scarborough on the north shore of Lake ontario during the period of November, 1965 to October, 1966. Precise photogrammetric mapping of the shorecliff topography was carried out for five sample reaches of shoreline, each with a different stratigraphic sequence. Comparative mapping for each sample was compiled from 1931, 1952 and 1964 aerial photography.

212. Horton, R. E. and C. E. Grunsky. 1927. Hydrology of the Great Lakes. Report of the Engineering Board of Review. Part 3, Appendix 2. Chicago, Illinois. 432 p.

Hydrology has to do with the occurrence and distribution of natural water resources and with their quantitative variations resulting from the operation of the hydrologic cycle--rainfall, runoff and evaporation. As related to the Great Lakes it involves the following elements:

1. Rainfall on the drainage basins tributary to the lakes.
2. Rainfall on the lake surface.
3. Evaporation from the lake surfaces.
4. Runoff and inflow to the lakes.
5. Outflow from the lakes.
6. Lake levels and their fluctuations.

Among the earliest measurements of outflow from the Great Lakes are those made under the direction of Col. J. Kearney of the U. S. Topographic Engineers, in October, 1856. He found the combined flow through the north, middle and south passes of the St. Clair River through St. Clair Flats, to be 212,000 cubic feet per second. Much more extensive measurements were made by D. Farrand Henry in 1865-69. Henry also made measurements of the evaporation at stations surrounding the lakes and undertook to determine the relation between runoff, inflow, rainfall, evaporation and outflow for Lakes Michigan and Huron. Beginning about 1896, numerous and reliable gagings of outflow from the different lakes have been made under the direction of the U. S. Lake Survey.

Complete records of lake levels extend back to 1860 and approximate records can be carried back to 1835. Extensive data of rainfall on the Great Lakes drainage basin have been maintained in the United States by the U. S. Weather Bureau, the longer records extending back to the beginning of lake level records. Similar records in Canada have been maintained by the Canadian Meteorological Service. Few data regarding runoff to the lakes from tributary streams are available prior to 1900.

Several attempts have been made to correlate the stage and discharge relations of the Great Lakes with the controlling factors--rainfall, evaporation and runoff. In general, it has not been possible heretofore to obtain satisfactory results from comparisons of inflow and outflow for want of some of the essential basic data, particularly records of runoff from tributary streams.

Attention is attarcted to this subject at the present time through a variety of causes:

1. The increasing importance of navigation of the Great Lakes.
2. The agitation for waterways connecting the Great Lakes with the Atlantic Ocean and the Gulf of Mexico.
3. The present low stages of the lakes.
4. The obvious need of lake level regulation, whether any water is diverted from the Great Lakes or not.

While higher minimum stages of the lakes are desirable, higher maximum stages may be undesirable. In general, a decrease in the range of fluctuation of lake levels through operation of regulating works must be accompanied by an increase in variation in discharge or vice versa. The problem of regulation is to maintain the highest practical minimum stages during the navigation season and the most desirable regimen of outflow compatable therewith without introducing objectionably high maximum stages or outflow velocities. The solution of this problem depends in a large measure on the range and magnitude of different types of variation in lake level, particularly variations due to natural secular variations of rainfall on the runoff from the lake drainage basins.

Changes or variations in lake levels are due to a variety of causes, which may be classified as natural or artificial. Variations due to natural causes include those resulting from variations in rainfall and evaporation, those due to ice conditions and erosion and transient variations due to barometric changes, wind action, seiches, currents, tides and waves. Artificial changes include those resulting from channel improvement, control works and diversions.

Variations in lake levels may also be conveniently classified according to their duration.

(a) Permanent
(b) Secular
(c) Seasonal
(d) Transient

Permanant changes may have resulted from tilting of the lake basins, erosion and artificial improvement of connecting channels, and from diversions. Secular changes are those of long duration, due principally to variations in rainfall and evaporation. Seasonal changes are due to the natural annual cycle of rainfall, runoff and evaporation and to the effect of ice conditions. Transient changes include those due to wind barometric variations, seiches, tides, currents and waves and in some cases, ice jams.

One of the objects of the study of the hydrology of the Great Lakes is to provide a basis for the more accurate evaluation of the effects of some of the more important causes of changes in lake levels. These include particularly the varying effects of rainfall, evaporation and ice conditions and the effect of improvement of the connecting channels between the lakes.

Aside from the secular changes in natural conditions, such as variations in annual rainfall, runoff and evaporation, there have been important geographic changes in the Lakes region in recent times. These include:

1. Deformation or tilting of the land surface, to which attention was directed by Dr. G. K. Gilbert many years ago.
2. Deformation and changes in agricultural conditions, particularly the possible effect of the cutting off of the primeval pine forest of northern Michigan.
3. Deepening and improvement of the lake outlets at control points, particularly on St. Clair and Detroit Rivers.
4. Artificial diversions from the lakes.

Some of these changes, such as channel improvement and diversions, are known to have affected the hydrology of the Great Lakes, and their effects can be quantitatively determined within certain limits of approximation.

While it may not be possible at the present time to determine with precision the effects of tilting and deforestation in relation to the hydrology of the Lakes, yet a discussion of this subject may serve to clarify the situation by showing at least the relative importance, or lack of importance, of these factors as compared with other factors affecting lake levels and outflow.

213. Hough, J. L. 1958. Geology of the Great Lakes. Univ. of Illinois Press, Urbana, Illinois. 313 p.

A very comprehensive book about Lake Ontario including the following parameters:

General Description
Depth
Bottom Topography
Geology
Wave Action
Tides
Surface Currents
Sediments
Lake Stages
Extensive Bibliography
Seiches & Short Period Fluctuations
Ice
Thermal Stratification

Precipitation
Evaporation
Chemistry

Pre Glacial & Glacial History
Maps

214. Hough, J. L. 1963. The prehistoric Great Lakes of North America. American Scientist. 51: 84-109.

The origin and evolution of the Great Lakes basins are discussed in depth in this article. The various lake stage-glacial retreat stages are depicted along with an explanation of basin flow characteristics and changes in them. The Great Lakes Basin originated presumably from large pre-glacial rivers in the area that were altered by the glaciers.

A discussion of post glacial activity is also presented showing the development of water systems and lake levels as we know them today.

215. Hyde, A. S. 1939. The ecology and economics of birds along the northern boundary of New York State. Roosevelt Wildlife Bulletin. 7(2): 66-215.

Basic information are presented on the geology and climatology of the northern boundary of New York State, much of which is along the St. Lawrence River and Lake Ontario. Mean summer monthly and annual precipitation temperatures and humidity are presented.

216. Hydro-Electric Power Commission of Ontario. 1965. Brief to International Joint Commission on Great Lakes levels. Toronto. 9 p. + graphs.

It is also felt that regulation could be a benefit to all users provided all lakes are regulated to a coordinated plan and that such a plan gives equitable consideration to the requirements of all users. Ontario Hydro, and therefore, Ontario, has large investments in hydroelectric plants on the lakes. As regulation could have a considerable effect on the output of these plants, it is respectfully requested that an opportunity be given this Commission to comment and advise on criteria on which the regulation studies will be based and on any proposed regulation plan while it is in the formative stages. (Univ. of Toronto, Great Lakes Institute).

217. International Joint Commission. 1951. Pollution of boundary Waters. Washington, D. C. 311 p.

This report, published by the International Joint Commission, presents data on Eastern Lake Erie, the Niagara River and Western Lake Ontario. The following parameters are presented: temperature, precipitation, average annual wind direction and velocity, and water turbidity. Practical information is also presented on the industrial and domestic uses of these waters and their biological, chemical and physical effects on the water quality of the area.

218. International Joint Commission. 1968. Interim report on the regulation of Great Lakes levels. Washington, D. C. 21 p.

A joint Canada-United States study on the water levels of the Great Lakes has been undertaken in response to a reference, dated October 7, 1964, to the International Joint Commission by the Governments of the two countries. The reference, a copy of which is appended hereto, requires a determination of whether measures within the Great Lakes Basin can be taken in the public interest to further regulate the levels of the Great Lakes or any of them and their connecting waters, so as to reduce the extremes of stage which have been experienced.

This interim report describes features of the lakes which relate to their levels; indicates the interests which make direct use of the lakes and are affected by lake level variations; discusses the problem of regulating the levels by controlling lake outflows; sets forth the nature, scope and progress to date of the Commissions study and indicates how it is oriented toward a comprehensive consideration, within the terms of reference of the many facets of the lake-regulation problem.

219. International Joint Commision. 1969. Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River. Washington, D. C. 3: 329.

The intensification of the pressures responsible for water pollution in the Lake Ontario basin are described. The projections of population growth and industrial developments indicate a probable doubling by 1986 of the raw waste loadings produced by municipalities and industries. Lane drainage has been cited as causing significant pollution problems but practical control measures are not yet readily available. Waste heat and losses of oil and industrial materials are not new problems, however, their magnitude has grown. It is clear that future requirements for cooling water and the discharge of large quantities of waste heat will pose serious questions on how to protect or preserve the ecological environments of nearshore waters. Industrial growth and increasing vessel traffic in the Great Lakes will create further potential hazards for spills of oil and hazardous materials unless precautions are taken to prevent such occurrences. Improvement in the quality of the water can be expected with phosphorus reduction in the drainage basin provided that the recommended implementation programs are developed and carried through by municipalities and industry.

220. International Joint Commission. 1970. Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River. Washington, D. C. 4: 174.

In depth discussion on biological and chemical parameters, with some basic information on drainage, sedimentation and water turbidity.

221. International Joint Commission. 1971. The Niagara River pollution abatement progress. Lake Erie, Lake Ontario Advisory Board. Washington, D. C. 62 p.

Although the Canadian side of the Niagara River is relatively pollution free, discolorization and oil pollution problems are still present near some outflows on the American side of the river. Industrial and domestic effluents are traced. Each of the major contaminants of the river are discussed, along with the effects on general river water quality.

Irbe, J. G. - See: T. L. Richards, No. 315.

222. Irbe, J. G. 1969. Some unusual surface water temperature patterns in the Great Lakes, as detected by airborne radiation thermometer surveys. Proceedings 12th Conference Great Lakes Research. pp. 583-607.

Since 1966, the meteorological service of Canada has undertaken a program of monthly surface water temperature surveys of the Great Lakes bordering on Canada using an airborne infra-red temperature sensing device. During the three year period that the program has been in progress, many interesting features of the distribution of surface water temperature have been found. Maps showing some of the more unusual isotherm patterns deduced from these surveys are presented and discussed with reference to lake circulation and meteorological conditions.

Isachsen, Y. W. - See: J. G. Broughton, No. 39.

Isachsen, Y. W. - See: D. W. Fisher, No. 172.

Izatt, J. B. - See: M. D. Palmer, No. 293.

Jekel, P. - See: J. T. Scott, No. 343.

223. Jiusto, James E. and E. W. Holroyd. 1970. Great Lakes snowstorms, Part I. - cloud physic aspects. Abstract of paper presented at the State University of New York, Atmospheric Sciences Research Center, Albany, New York. p. 10.

Lightning discharges observed in Great Lakes snowstorms during early winter can be explained by heavy riming of crystals. Based on field observations and calculations, the following criteria appear essential for the phenomenon:

(a) Supercooled clouds with a large water-to-ice ratio (clouds close to water saturation).
(b) The presence of large graupel pellets (conical shapes appear particularly favourable for charge separation).
(c) Cloud thickness of at least 3-4 km.
(d) Relatively extensive cloud cells (radar echoes with 10 km or more horizontal dimensions).

In essence, items (a) and (c) provide for the effective growth of graupel to large sizes, and item (d) enables a sufficient volume of cloud togenerate a total critical charge of about 1000 C (Mason, 1962). The above conditions are satisfied during the early winter season--November and December--when in fact lightening is observed. As reported in the snowfall climatology discussion, these intense storms produce 2 to 5 times more snowfall than late winter storms.

224. Jiusto, James E. and M. L. Kaplan. 1970. Snowfall characteristics of Great Lakes storms. Abstract of paper Proceedings 27th Annual Meeting Eastern Snow Conference, Albany, New York (February, 1970).

Snowfall data downwind of Lakes Erie and Ontario were analyzed for 26 individual "lake effect" storms during the three-year period 1966-68. This beginning climatology included arial distributions of total snowfalls, snowfall depth to meltwater ratios and total meltwater values. A statistical analysis was performed to explore the influence of cloud microphysical, seasonal (temperature), and topographic factors on these snowfall characteristics. Relationships were also sought between upper-air flow patterns and total volumetric water output per storm. (Canada Centre for Inland Waters).

223. Jiusto, James E., D. A. Paine and M. L. Kaplan. 1970. Great Lakes snowstorms, Part 2. Synoptic and climatological aspects. Abstract of a paper presented at Atmospheric Sciences Research Center, State University of New York, Albany. 58 p.

A climatological study of three years of lake-storm precipitation data served to solidify certain previously held ideas on storm behaviour and to introduce some new findings. Snowfall distributions in the vicinity of Lake Erie and Lake Ontario are indeed dependent on air trajectory, with the greatest snowfall amounts being associated with southwest to westerly winds and a single intense snowband. Each of these intense storms generates an average of approximately 3 x 10^{12} lbs. of water and a snowfall area of approximately 50,000 nautical mi^2 (both lake regions combined). Storms associated with northwesterly winds, consisting of multiple less-intense bands, produce dome 50% less total precipitation on average, with the snowfall spread over a somewhat greater area. Orographic effects, while a factor in snowfall accumulations, generally appear less important than lake-induced and synoptic-scale (vorticity advection) influences.

Snow crystal type, as deduced from snowfall density (snow depth to meltwater ratio), is highly variable within a given storm as well as from storm to storm. The data indicate that rimed crystals and graupel are common close to the Lakes during November and early December, while snowflakes (aggregates) become the dominant crystal type further inland. As the winter season progresses and lake and air temperatures decrease, rimed crystal forms become far less common. These results are compatible with sparse field observations.

Water budget analyses show a strong correlation between amount of snowfall and time of year, with January storms being 2 to 5 times less productive than early-season snows. A steady decline in lake temperature and in air-water temperature difference are largely responsible and obviously result in reduced vertical fluxes of moisture and thermal energy. Perhaps no better sample of the impace of these water bodies on Great Lakes snowstorms can be given. (Canada Centre for Inland Waters).

226. Johnson, E. C. and C. P. Mooh. 1953. The heavy snowfall of January 28-30th, 1953, at the eastern end of Lake Ontario. Monthly Weather Review. 81(1): 26-30.

On January 28 and 29, 1953, three feet of snow fell in a 20 mile wide east west band centering around Polaksi, New York. The following situations were thought to be responsible:

1. Polar air over Lake Ontario on January 28 brought snow to Polaski.
2. An east-north-east shift on the 29th centered the storm around Adams, New York with an accompanying 9" of snowfall.
3. A shift back toward Polaski gave the area another 2" of snow.
4. A final shift to the east-south-east on the 29th and 30th brought 1 foot of snow to the area of Fulton and Syracuse.
5. The temperature difference between air and Lake Ontario water was always greater than 10°F.

The snow was of light density causing severe blowing and drifting.

227. Johnston, R. H. 1964. Ground water in the Niagara Falls area, New York. U. S. Geological Survey, New York State Conservation Department. Water Resources Commission, Bulletin GW-53. Unnumbered.

Glacial deposits in the Niagara Falls area consist of (1) glacial till, (2) lake deposits, (3) a few small sand and gravel deposits. The bedrock is Lockport Dolomite and Queenston Shale. The Lockport Dolomite is the only important aquifer. The water is found in verticle and horizontal joints in the rocks, as well as small cavities from which gypsum has been dissolved. There are seven distinct water bearing zones in the area. (Schoellkopf Museum, Niagara Falls, New York).

Jurkovec, A. A. - See: A. S. Menon, No. 269.

Kamitakahara, G. K. - See: W. G. Simpson, No. 350.

Kammerer, J. C. - See: B. K. Gilbert, No. 178.

Kaplan, M. L. - See: J. E. Jiusto, No. 224, 225.

228. Karrow, P., J. R. Clark and J. Terasmae. 1961. The age of Lake Iroquois and Lake Ontario. Journal of Geology. 69: 659-667.

Recent geological and engineering investigations at Hamilton, Ontario have resulted in the discovery of buried plant bearing beds in deposits of Lake Iroquois and Lake Ontario. Fossils in these beds indicate cold, shallow water conditions of sedimentation for the earlier deposited beds and warmer conditions for later deposited layers. Radiocarbon dating of buried wood suggests that Lake Iroquois was formed during the retreat of Port Huron ice. The Valders drift boundry is inferred to be north of Lake Ontario. Lake Ontario probably originated over 10,000 years ago.

Kemp, A. L. W. - See: R. L. Thomas, No. 389.

229. Kemp, A. L. W. 1969. Organic matter in the sediments of Lakes Erie and Ontario. Proceedings 12th Conference Great Lakes Research. pp. 237-249.

Six piston core samples were taken in Lake Ontario. The basin sediments consisted of black laminated grey silty clay, with mud thicknesses ranging from 4.6-13.8 m in the cores. A diagramatic profile is presented in the paper.

230. Kemp, A. L. W. 1971. Organic carbon and nitrogen in the surface sediments of Lake Ontario, Erie and Huron. Journal of Sedimentary Petrology. 41(2): 537-548.

Analysis of 355 surface sediment samples (top cm) from Lake Ontario, Erie and Huron. Similar analysis were carried out in a representative core from each lake at close intervals down to 20 cm. Sediment texture, properties and materials are discussed.

231. Kemp, A. L. W. and C. F. M. Lewis. 1968. A preliminary investigation of chlorophyll degregation products in the sediments of Lakes Erie and Ontario. Proceedings 11th Conference Great Lakes Research. pp. 206-229.

Studies of thirty seven surface sediment samples. Sub environments within the lake are recognized on the basis of bathymetry, sediment particle size distribution, clay mineral content and mud thickness.

Kennedy, R. J. - See: A. Brebner, No. 38.

232. Kilgour, W. J. 1963. Lower Clinton (Silurian) relationships in western New York and Ontario. Bulletin of the Geological Society of America. 74: 1127-1142.

A new interpretation of Silurian Lower Clinton relationships observed in the area between Medina, New York, and Clappison's Corners, Ontario, is presented. The Lower Clinton Group in this area is considered to include those units between the Thorold Sandstone and the Irondequoit Limestone. The profound lithological and faunal differences between the Lower Clinton strata of western New York and those of the Niagara Peninsula in Ontario are probably the result of deposition in a shallow basin under conditions controlled by proximity to the Cataract shelf (Bolton, 1957). The influence of this shelf extended south and east of Hamilton, Ontario; its effect was felt at the beginning of Early Clinton time. Frequent slight changes in the elevation of the shelf area and the nearby depositional basin to the south and east resulted in fluctuations in strand lines and reworking and removal of some units. Supporting evidence includes thin conglomerates at several contacts, wedging out or overlap of lithologic units and changes in fauna of successive units.

The Reynales Formation between Medina, New York and Clappison's Corner, Ontario, is restricted and redefined to include only the lower, fossiliferous, limestone units which are here designated the Hickory Corners Limestone Member (new name) and the Merritton Limestone Member (new name). The upper more dolomitic and less fossiliferous unit, herein named the Rockway Dolomite Member (new name), is removed from the Reynales and is considered to be the lower member of the Upper Clinton Irondequoit Limestone.

Kilpatrick, T. B. - See: D. C. Archibald, No. 17, 18,
19, 20, 21, 22.

233. Kindle, E. M. 1915a. Limestone solution on the bottom of Lake Ontario. American Journal of Science. 39: 651-656.

Pitted limestone rocks found at a depth of 150-200 ft. southwest of Brighton, Ontario indicate a lack of deposit on bottom and strong scouring action on the limestone by deep currents. Sixteen miles of Presque Isle.

234. Kindle, E. M. 1915b. Notes on bottom currents in Lake Ontario. American Journal of Science. 39: 192-196.

Using ripple mark molds underwater, a wind direction current direction correlation is derived for the Toronto area of Lake Ontario.

Wind	Current
north/northwest	variable
northeast/east/southeast	southwest
south/southwest/west	northwesterly

Preaque Isle and Wellington Bay had currents in the westerly direction at approximately 4 1/2 miles per hour.

235. Kindle, E. M. 1925. The bottom deposits of Lake Ontario. Transactions Royal Society of Canada, 3d Series. 19(4): 47-102.

The material covered includes, general lake features (Phisiographic features, water temperature, materials of the lake shore and its recession), distribution factors such as wind and currents, physical bottom features (sedimentation, depth and distance factors on sedimentation, sediment analysis), and organic bottom features which includes some data in light penetration (by visual analysis).

236. Kindle, E. M. A comparative study of different types of thermal stratification in lakes and their influence on the formation of marl. Journal of Geology. 37(2): 150-157.

The results of an investigation of thermal stratification in Lakes Ontario and Huron are compared with the thermal stratification which characterizes small lakes in the Ottawa Valley. The warm surface zones of the Great Lakes is much thicker than those of the smaller lakes. The relatively low temperature of the Great Lakes epilimnion zones prevents marl bed formations.

237. Kindle, E. M. and F. B. Taylor. 1913. Geologic atlas of the U. S. - Niagara folio. Department of Interior, Geological Survey. 38 p.

The geology, age determinations, stratigraphy, locations, dimensions and evolution of the Niagara Folio area of Western New York. The area covered includes much of Niagara Falls, the lower Niagara River, Lake Ontario

(Niagara Delta area) and shore areas east of the Niagara River Delta. (Schoellkopf Museum, Niagara Falls, N. Y.).

238. Kirchgatter, D. 1958. Factors responsible for the recession of the Scarborough Bluffs shoreline. Canadian Department of Lands and Forests. 24 p.

The total area has been traversed by foot as the base of the cliffs and to the greater part by car and by foot along the summit. Contrary to frequently expressed opinions it was found that in no case waves, or better breakers were the responsible factors of erosion. This is within the limitation that we presently experience a comparatively low lake level. The main factors we consider today are surface water runoff, water seeping out on the face of the cliff, wind erosion in parts, gullying and possibly the nesting of cliff swallows and the advent of the building of houses and roads, etc., close to shoreline. The answer to counteract erosion might be in maintaining low water levels, artifically sloping off pronounced steep cliffs, providing drainage for them, and to keep any man-made construction well distanced from the edge of the cliff.

239. Kirshner, L. D. 1968. Effects of diversions on the Great Lakes. U. S. Army Corps of Engineers, Lake Survey Report 68-7. 33 p.

Effects of diversions on the levels and outflows of Lakes connected by channels affected by backwater, such as Lakes Michigan, Huron and Erie in the Great Lakes system, are discussed. The diversions considered consist of diversions into and out of the drainage basin of the lakes and of diversions between the lakes. The histories and features of the five existing diversions in the Great Lakes basin that meet these conditions are outlined. It is pointed out that the full effects of such diversions are not immediate upon initiation of the diversion but are progressive over a period of time, depending upon the surface areas and the lake level-lake outflow relationships of the lakes involved. This period is, for example, about 15 years for Lake Michigan and Lake Huron diversions. The methods used by the U. S. Lake Survey to determine the progressive and ultimate effects of diversions in connection with studies of the International Joint Commission of the United States and Canada are described. The equations employed and the results in graphical form are shown. The ultimate effects of the Great Lakes diversions upon their levels and outflow, which have already been reached, are listed. General commentary is made upon the effects of high and low lake levels and outflows in the three major Great Lakes interests - riporian properties, navigation and hydroelectric power - that are concerned with the levels and outflows and upon the manner in which increases and decreases in lake levels and outflows resulting from diversions increase or decrease the effect. (Canada Centre for Inland Waters).

240. Kiwanas Club of Stamford, Ontario. 1967. Niagara Falls, Canada. Centennial Volume, Niagara Falls, Ontario. 452 p.

A history of human development of the Ontario side of the Niagara River. Included is some material on geology, river characteristic and evolution. (Schoellkopf Museum, Niagara Falls, New York).

241. Kramer, J. R. 1966. Equilibrium models and composition of the Great Lakes. Equilibrium concepts in natural water systems. American Chemical Society, Washington, D. C. pp. 243-254.

To a good first approximation, the Great Lakes fit a model involving the equilibrium of calcite, dolomite, apatite, Kaolinite, gibbsite, Na and K Feldspars at 5°C, 1 atmosphere total pressure with air of $Pco_2 = 3.5 \times 10^{-4}$ atmospheres and water. Dynamic models, considering carbon dioxide pressure and temperature as variables, show that cold waters contain excess carbon dioxide and are unsaturated with respect to calcite, dolomite and apatite, whereas warm waters are nearly at equilibrium with the atmosphere but somewhat supersaturated with respect to calcite, dolomite and apatite.

242. Ku, L. F. 1970. Spectra of monthly mean water level in the Great Lakes. Proceedings 13th Conference Great Lakes Research. pp. 844-861.

The annual variation sa and its harmonics appear significantly in the spectra of monthly mean water level in the Great Lakes. The energy of the spectra is concentrated in low frequencies and the plots of background in the spectra at all stations are similar. The coherent energy between Lake Superior and each of the other lakes is relatively lower than that of other pairs. The phase sa increases from east to west. In Lake Superior it lags about two months behind Lake Ontario. The amplitude of sa computed by least squares decreases as the number of points increases. The value of sa in Lake Ontario is 12 cm. larger than that of Lake Huron (6 cm). Owing to the relatively small contribution to the variance by the annual term and its harmonics, it is not practicle to predict the monthly mean water level using only the periodic components.

Lambert, Y. T. - See: D. V. Anderson, No. 12.

Landsberg, D. R. - See: J. T. Scott, No. 344.

243. Landsberg, D. R., J. T. Scott and M. Fenlon. 1970. Summer circulation patterns near Nine Mile Point, Lake Ontario. Proceedings 13th Conference Great Lakes Research. pp. 444-452.

Measurement of current speed and direction by current meter and drogues were obtained in July and August 1969 on three buoy lines located near East Nine Mile Point on the south shore of Lake Ontario. Transport was found to be northeastward forming a coastal current with speeds from 5-40 cm/sec. The speed of this current decreased rapidly below the thermocline. The coastal current was weaker near Nine Mile Point than 10-30 km. west because this current turns northward near Oswego. The dynamic height pattern shows a countercurrent forming as eddy west of Nine Mile Point.

Lane, R. K. - See: N. J. Campbell, No. 50.

Lane, R. K. - See: F. C. Elder, No. 165.

244. Lane, R. K. 1970. Great Lakes thermal studies using infrared imagery. Limnology and Oceanography. 15(2): 296-300.

Examples of mosaics of infrared imagery of the western end of Lake Ontario are used to demonstrate their value in revealing detailed surface thermal patterns. Additional data from airborne thermometry and shipboard measurements confirm the interpretation of large-scale dynamic processes. Smaller scale phenomena, such as internal wave patterns and small eddies, are also interpretable. (Canada Centre for Inland Waters).

245. Langbein, W. B., et. al. 1947. Major winter and non-winter floods in selected basins in New York and Pennsylvania. U. S. Geological Survey Water Supply Paper 915. 139 p.

The scientific design of flood control works are based on an evaluation of the hydrologic factors basic to flood events, among which are snowfall, rainfall, soil conditions and channel influences. Precipitation, temperature, geology, climatology and stream characteristics are studied for 8 basins in Pennsylvania and New York.

246. Langford, G. B. 1952. Report on lakeshore erosion - Part I - Lake Ontario from Niagara to Cobourg. Department of Planning and Development, Province of Ontario, Toronto, Ontario. 36 p.

Periods of high water accelerate the process of shore erosion, emphasizing the destructive capacity of waves. Two high water stages have been reported; one in 1929-30, the other in 1943-48. Governmental awareness, legislation, engineering studies for protective measures and lake current studies should be initiated to combat the problem. Recession rates, geological formations and materials, and water level data are presented for all the major geological areas within the shoreline area from Niagara to Cobourg. (Canada Centre for Inland Waters).

Lansing, L. - See: J. T. Scott, No. 345.

247. Lansing, L. 1965. Air mass modification by Lake Ontario during the April-November period. Great Lakes Research Division, Univ. of Michigan Publication 13. pp. 257-261.

This paper discusses the important role the Great Lakes play on the weather and the climate modifications of the surrounding air masses, by means of a study of the northeastern region of Lake Ontario. The study describes the changing patterns of air mass modifications as the season progresses through spring, the heat of mid-summer to late fall, which ice begins to form in the harbors of the lake. It is indicated that the lake plays a more important role on the modification of air masses in the fall and early winter.

248. Laverett, F. 1902. Glacial formations and drawings features of the Erie and Ohio basins. U. S. Geological Survey, Monogram 41. 802 p.

This survey covers the southern shore area of Lake Ontario from the Niagara to the Genesee Rivers. Special emphasis is on drainage system features in the area (direction, volume, variation). A brief history is given of glacial movement and lake formation and an extensive geological bibliography is presented. Data is presented on age and composition of geological formations.

249. Laverett, F. and F. B. Taylor. 1915. The Pleistocene of Indiana and Michigan and the history of the Great Lakes. U. S. Geological Survey, Washington, D. C. 529 p.

This report is a lengthy statement of the glacial lakes and processes occurring in the Great Lakes region resulting in the formation of the lakes as we know them today. The discussion includes, ice characteristics, erosion, changes in topography, geology, glacial deposits and lake levels.

Lee, A. H. - See: G. K. Rodgers, No. 330.

250. Lemire, F. 1961. Winds on the Great Lakes. Great Lakes Institute, Univ. of Toronto. PR-2. 11 p.

This project was carried out with two main objectives in mind. The first was to calculate the ratio of the winds over water to those over land. The second was to compare the actual observed wind velocities with those calculated from surface weather maps.

The results of the first analysis of winds over water and over land showed that there is a good relationship and that this relationship displays two strong variations - diurnal and seasonal. The ratio R varies during the day from a maximum at approximately 00 E.S.T. to a minimum at 13-14 E.S.T. This ratio R also displays a seasonal variation from a maximum during December-January to a minimum during July-August. After comparing all results obtained, we find that regardless of the lake chosen, the average values for the ratios were:

$\bar{R}$ fall = 1.9 and $\bar{R}$ spring = 1.6

In regard to the relationship between the observed winds and those calculated from the surface weather maps, we have also found a good correlation. This ratio has only one discernible variation - it varies inversely as the magnitude of the observed wind and this relationship is approximately linear. The average value of the ratio R_1 (where R_1 = geostrophic wind speed/observed wind speed)[1] was found to be approximately 1.4. That is to say, for a case of indifferent stability the geostrophic wind calculation would likely be greater than the observed winds by a factor of 1.4. This result seems to be fairly consistent with the generally accepted ratio of three halves (5, 8).

Lewis, C. F. M. - See: A. L. W. Kemp, No. 231.

Lewis, C. F. M. - See: R. L. Thomas, No. 389.

251. Lewis, C. F. M. and R. N. McNeely. 1967. Survey of Lake Ontario bottom deposits. Proceedings 10th Conference Great Lakes Research. pp. 133-142.

Short gravity cores and grab samples recovered during a continuing reconnaissance survey initiated in 1966, were used to study the distribution, stratigraphy and chronology of Lake Ontario bottom deposits. Three major groups of surficial deposits were recognized: 1) complex nearshore sediment, 2) glaciolacustrine clays, 3) post glacial muds. Organic content of 2-6% and median particle diameters of 1-4 microns are typical of the offshore surficial muds. Pollen in these sediments facilitates correlation and subdivision and indicates that the present sedimentation rate in the main basin is approximately 10 cm per century. Several sediment sequences indicate and confirm the post glacial low level. Admirality Lake stage and suggests it may have reached lower levels than previously believed.

252. Lewis, C. F. M. 1968. Quaternary geology of the Great Lakes. Geological Survey of Canada, Paper 68-1. Report of activities, Part A: April-October. pp. 63-64.

A major coring and echo sounding program in Lake Ontario yielded piston cores up to 60 feet in length from representative areas of mud throughout the lake. The departmental vessel C.S.S. Limnos proved to be an ideal platform for these operations. A variety of shallow water environments were indicated.

253. Lewis, C. F. M. 1971. Stratigraphy and sedimentation from seismic profiling in the Toronto waterfront area of Lake Ontario. Abstract of paper presented at 14th Conference Great Lakes Research, Toronto, April 19-21, 1971. pp. 168-169.

Between Humber Bay and Scarborough, the lake bottom shelves gently offshore into depths of 9 to 23 m. This shelf is veneered with sand and/or gravel, and glacial sediments locally outcrop. Bar forming processes may be active on the shallow shelf and profiles indicate an irregular bottom topography. A pronounced break in slope terminated the shelf in the form of a bold scarp feature.

Bedrock outcrops on the shoreline at Minico, elsewhere in the Toronto area it lies 6-30 m below the lake level, and slopes gently offshore at a slightly greater rate.

254. Lewis, J. M. 1963. The present state of knowledge of the Great Lakes current system. M. S. Dissertation, Univ. of Chicago, Chicago, Illinois. 50 p.

An attempt has been made to summarize the work that has been done on the Great Lakes current system. The summary includes the technological aspects of current measurement, as well as the research that has resulted from data collection and analysis. In addition, the agents of current production have been classified under two main headings, viz., meteorological effects and geophysical effects. Under meteorological effects of seiche activity and wind are considered while the effects of geological setting, bottom topography and the earth's rotation are discussed under the heading of geophysical influences. (Canada Centre for Inland Waters).

Lewis, T. L. - See: R. G. Sutton, No. 373.

Lipton, S. D. - See: R. C. Bubeck, No. 47.

255. Liu, P. C. 1970. Statistics of Great Lakes levels. Proceedings 13th Conference Great Lakes Research. pp. 360-368.

Spectral analysis of monthly water level data in the frequency range of 0-6 cycles per year reveals that significant peaks of annual cycles exist in all the lakes. Spectra obtained by taking the differences between the monthly data and long term average for the same months do not contain any prominent peaks. Spectral analysis of annual water level data in the frequency range between 0-1/2 cycles per tear suggests the existence of a long term periodic cycle of eight years.

Loewen, P. - See: T. L. Richards, No. 316.

256. Luther, D. O. Undated. Geologic map of the Buffalo quadrangle. New York State Museum, Bulletin 99. 26 p.

The map presented gives accurate data in regard to the surface rocks and succession of strata at and in the immediate neighborhood of Buffalo. The map and its accompanying text give a detailed guide to the rock sections of the region and to the scattered and often obscure outcrops of the formations.

The Buffalo quadrangle embraces geologic formations which extend from the Upper Siluric well into the Upper Devonic. The rocks abound in fossils which have been cited under their respective formation names.

257. Mack, Frederick K. and Ralph E. Digman. 1962. The ground water resources of Ontario County, New York. U. S. Geological Survey, Bulletin GW-48. 99 p.

Ontario County is located in the Ontario Lake Plain in the north and the Finger Lakes region in the south. Both the consolidated bedrock and the unconsolidated deposits which overlie the bedrock are sources of ground water available from any of these sources depends on the thickness, lateral extent, permeability, topographic setting, lithology and location of the aquifer.

MacKenzie, R. J. D. - See: G. C. Dohler, No. 159.

258. Martin, J. O. 1901. The Ontario coast between Fairhaven and Sodus Bay, New York. American Geologist. 27(6): 331-334.

In the area between Fairhaven and Sodus Bay, large bluffs are visible from the lake. The bluffs consist of clay and Medina Sandstone with lake beaches consisting of gravel and boulders. Wave action apparently erodes the bluffs from a few inches to ten feet per year. Behind the bluffs, ponds and lagoons are formed during high water and flow out in low lake level times. The shoreline in the area has been eroded from 1/4 to 1/2 mile in this area since formation of the lake as we know it today.

Massey, D. G. - See: T. L. Richards, No. 315.

Matheson, D. H. - See: D. V. Anderson, No. 13.

259. Matheson, D. H. 1958. A consolidated report on Burlinton Bay. Municipal Laboratories, Corporation City of Hamilton, Ontario, Canada. 110 p.

This report includes watershed features:

1. Description.
2. Morphometry (water depth and area covered).
3. Ground water characteristics (chemical and physical properties).
4. Tributaries (characteristics, size and flow).
5. Marsh, bay and general water analysis.
6. Meteorological data (precipitation and water levels).
7. Runoff.

The general physical parameters include: temperature, both surface and stratification and turbidity. The turbidity levels indicated a serious problem with some bay areas containing five times as much suspended matter as the adjacent lakes areas.

260. Matheson, D. H. 1962. A pollution study of western Lake Ontario. Great Lakes Research Division, Univ. of Michigan, Publication 9. pp. 15-20.

Three tracers were used to study the emission and distribution of polluted water from Hamilton Bay into Lake Ontario. The pollutants studied were: ammonia, coliform bacteria and synthetic detergent.

261. Matheson, D. H. 1963. A sanitary survey study of western end of Lake Ontario, 1961-63. Water Works Intakes. City of Hamilton, Ontario, Canada. 109 p.

Temperature, lake levels, sustained oscillations, currents, winds and thermal structure were all studied by the City of Hamilton, Ontario, during the period of 1961-1963.

Seasonal variation was from 247.9 ft. in June and July to 243.5 ft. in the winter months. The yearly difference is approximately four feet between high and low levels. Uninodal oscillations had a period of 5.41 hours while that of binodal oscillations was 2.48 hours.

The currents on the surface varied with wind variation indicating a direct relationship between the two.

Thermal structure showed seasonal variations following that of larger lakes.

262. Matheson, D. H. and D. V. Anderson. 1965. Circulation and water quality of western Lake Ontario. Ontario Department of Lands and Forests. Research Report No. 62. pp. 1-36.

In designing water intakes from lakes and associated treatment plants, a knowledge of the character of the water is useful. This is especially true where lake waters are liable to pollution and where there are wide daily and monthly variations in physical characteristics. In preparation for a new intake at Hamilton, Ontario, surveys were conducted in 1960 of the waters of the lake nearby. Measurements of circulation, temperature and of various chemical constituents made in these surveys are reported here.

263. McAndrews, J. H. Unpublished. Pollen analysis of the sediments of Lake Ontario. For publication by the 24th International Geological Congress. Unnumbered.

Analyses were made on 91 surface sediment samples and values were derived of both percentages and concentrations (grains per gram dry sediment) of 61 taxa. Concentration was highest, over 80,000, in the deep-water clays but was less than 40,000 in shallow, near-shore silts and sands. Pollen of ragweed and tree pollen, dominate the relatively uniform assemblage, however, significant percentage variations reflect nearness to upland source regions, river discharges and recycling of sediment.

Two deep-water (over 180 m) cores at stations 80 km apart penetrate 5 to 7 m of postglacial sediment and 9 to 11 m of late-glacial sediment. Eight pollen assemblage zones are present and correlate with radiocarbon and varve dated pollen assemblages from sediment of nearby small lakes. The pollen concentration of the seven postglacial zones is 35 times greater than the late-glacial spruce zone reflecting both greater pollen influx and the lesser rate of matrix accumulation. The ragweed zone begins at a depth 15 to 20 cm from the surface and represents forest clearance around the Lake beginning in the early 19th century. (Royal Ontario Museum, Toronto).

264. McCombie, A. M. 1967. Some physical and chemical characteristics of the Bay of Quinte. Ontario Department of Lands and Forests, Research Branch. Report No. 79. 56 p.

There is danger that the Bay of Quinte will become eutrophied to the point where the fish populations are endangered. Accordingly, the research branch of the Ontario Department of Lands and Forests undertook to study certain aspects of the Physics, Chemistry and Phytoplankton of the Bay during the summers of 1963-1964, in order to compare present conditions with those reported in earlier investigations, by Tucker (1949) and Pal (1958). Physical studies included temperature and specific conductivities. Surface waters attain their greatest temperature in the third week of July. The innermost portions of the Bay were generally warmer. Specific conductance of the outer Bay area was generally greater than in the inner Bay.

In conclusive, secchi disc readings were also taken.

265. McCrindle, W. E. 1961. A study of some bottom deposits from Lake Ontario. M. S. Thesis, Department of Geology, Univ. of Toronto. 42 p.

Sediment samples taken from the bottom of Lake Ontario off Scarborough Bluffs were subjected to mechanical and mineralogical analyses in an attempt to show relationships between the sediments and distance from shore, depth of water, currents and wave action. It was concluded that the sources of material deposited on the bottom of Lake Ontario in the area studied are: (1) shore erosion, (2) streams, (3) erosion on the lake floor. Tables included show results of mineralogical analysis; grain size distribution vs. distance from shore; and heavy minerals vs. distance from shore. (Canada Centre for Inland Waters).

McIntyre, D. R. - See: T. L. Richards, No. 313.

266. McVehil, G. E., C. W. Rodgers and W. J. Eadie. 1968. The structure and dynamics of lake effects snowstorms. Cornell Aeronautical Laboratory, Inc., Buffalo, New York. Report No. VC-2559-P-1. 49 p.

A correlation is made between lake water parameters and climatology to produce favorable conditions for a "lake effect" snowstorm. The storms generally occur on the eastern edge of a lake when a northwesterly wind is pushing cold arctic air over warm water of the lakes. Snow characteristics are also discussed in reference to structure and occurrence.

Megerian, E. - See: B. G. DeCooke, No. 151.

267. Megerian, E. 1964. Forecasting Great Lakes levels - second through sixth month. Great Lakes Research Division, Univ. of Michigan, Publication No. 11. pp. 238-252.

A previous forecasting model presented in this series failed to account for the adverse meteorological conditions which often prevail over the lakes. The method used in this paper assumes periodic changes in conditions, consequently the hypothetical normal values are also changing. Hence, the most probable amount of net basin supply can be determined on a monthly or yearly basis utilizing trend analysis.

268. Megerian, E. and R. L. Pentland. 1968. Simulation of Great Lakes basin water supplies. U. S. Lake Survey, Army Corps of Engineers, Detroit, Michigan. MP 68-2. 6 p.

The basic concept utilized in the simulation study is to evaluate statistically the recorded supplies to isolate the two components assumed to constitute the basin water supply: (1) That portion of the supply that is considered randon, owing to chance interaction of unpredictable meteorological elements, and (2) That portion of the supply that is the result of the persistence due to natural storage in the lakes, soil, bedrock and snow over the drainage basin. In this study, consideration was also given to the relationship between supplies in neighboring basins. These factors are used to formulate mathematical models for simulation of supplies to all of the Great Lakes simultaneously. Extensive statistical tests have been used to ensure that the statistical parameters and the time series characteristics of the simulated data resemble those of the recorded data.

269. Menon. A. S., B. J. Dutka and A. A. Jurkovec. 1970. Preliminary studies on the effects of the Lake Ontario thermal bar in confining bacteria to the near-shore region. Division of Public Health Engineering, Department of National Health and Welfare. Manuscript Report No. KR. 70-2. 25 p.

Investigations into the thermal structure and heat budget of Lake Ontario by G. K. Rodgers and D. V. Anderson resulted in the discovery and identification of a phenomenon known as a thermal bar. In May, 1970, a study was undertaken to assess the influence of the thermal bar in confining bacteria to the near-shore area, during the spring period of rapid growth. The impetus for this bacteriological study, was the realization that the barrier effect of the thermal bar might have serious economic and health implications. That is, effluents discharged into the near-shore area would not be diluted as would occur under normal conditions but would be contained by the barrier effect of the thermal bar.

Two preliminary studies were undertaken to investigate the containing effect of the thermal bar. In the "time series study," two anchor stations, one on either side of the thermal bar, were sampled during alternate 24 hour periods at 4 hour intervals for 48 hours. Parameters studied in this investigation were total coliforms, fecal coliforms, 20°C MF plate count and bacterial biomass.

In the second study, a tracer bacteria, *Serratia marcescens* was released, 10 meters below the surface, inshore of the thermal bar; then at varying time intervals water samples were collected from mobile stations on both sides of the thermal bar. During this study, water samples were tested for total coliforms, 20°C MF plate counts, *S. marcescens* MF and *S. marcescens* presence-absence test.

From the data collected during this preliminary study, it could be shown that the thermal bar did have an effect on bacterial densities in the study area. Great differences in bacterial densities and biomass were observed between samples collected inshore and those collected off-shore of the thermal bar. Attempts were made to correlate diurnal changes with variations in bacterial densities; however, during this study, fluctuations in bacterial densities at the two anchor sample stations do not appear to be linked to diurnal changes.

The feasibility of using S. marcescens to follow the movement of bacteria in a lake was aptly demonstrated by the recovery of the tracer organism at Station S_c, six hours after being released. Recovery of S. marcescens at the one inshore station, although suggestive, cannot be considered supportive evidence for the suspected barrier effect of the thermal bar. Further studies with more intensive tracking of the tracer organism are planned for 1971.

From these preliminary studies, it would appear that the thermal bar acts as a barrier, separating the warmer more productive inshore waters from the mid-lake waters and also may retard or inhibit the diffusion of bacteria from the inshore to the offshore area.

270. Millar, F. G. 1952. Surface temperatures on the Great Lakes. Journal of Fisheries Research Board of Canada. 9: 329-376.

Thermographs were installed on the intakes of several steamships on the Great Lakes with which the H_2O temp. was recorded for 5-10 years. Averages are presented in tables, maps and diagrams. The temperature varies considerably over a lake surface in a manner determined by depths and currents. Standard Deviation and serial correlations are found for some of the data.

271. Miller, W. J. 1924. The geological history of New York State. New York State Museum. Bulletin No. 168. 148 p.

The glacial, preglacial and post-glacial history of New York State are discussed. The article contains data on geology, geological formation and evolution, erosion, glaciation and the various ice ages.

Monsinger, M. N. - See: D. C. Archibald, No. 17, 18, 19, 20, 21, 22.

Mooh, C. P. - See: E. C. Johnson, No. 226.

272. Mortimer, C. H. 1971. Large-scale oscillatory motions and seasonal temperature changes in Lake Michigan and Lake Ontario. Univer. of Wisconsin-Milwaukee, Center for Great Lakes Studies, Special Report No. 12. 106 p.

Chapter 1 outlines the annual thermal cycle in Lakes Michigan and Ontario.

The second chapter starts with a description of upwelling in a small lake and as modified by the Coriolis force in Lake Ontario and Lake Michigan. Depending on wind direction, upwelling can occur on either shore, accompanied by a downward tilt (downwelling) of the isotherms on the opposite shore. A clear correlation between upwelling occurrences and the speed, direction and timing of the wind stress is illustrated for Lake Michigan. By analogy with the generation of internal seiches by wind in small lakes, the principal responses of Lake Ontario and Lake Michigan to impulsive wind stresses are predicted to contain large contributions from the lowest odd-numbered, free internal (horizontal) modes, with the proportionality of the model contributions determined by the particular shape of the thermocline surface as displaced by the wind stress, and on the duration and periodic content of the wind impulses. An increase in internal wave activity after storms is demonstrated.

In Chapter 3, the theory is discussed of long internal waves in channels and basins in which rotation effects are important. The chapter was prepared in collaboration with Dr. M. A. Johnson of the British National Institute of Oceanography. Equations governing the wave motion are given and simplifying boundary conditions and assumptions are discussed. The solutions to the wave equation found by Kelvin, Poincare and Sverdrup are considered. The Sverdrup solution or wave, only satisfies the equation at points remote from the shore. The Kelvin solution is imposed by the presence of a boundary at which the normal fluid velocity component must be zero. Pairs of Sverdrup waves can be combined to satisfy the boundary conditions in a channel and two types of these are either standing waves or progressive waves; in either case, these are called Poincare waves. The characteristics of the various types of wave motion are discussed in this chapter, and their respective zones of activity are examined. In Lake Ontario, the limitations on the present models are not considered to be serious, but produce modifications or damping of wave patterns as predicted by the models discussed.

The observations in Lakes Michigan and Ontario temperature oscillations and currents are interpreted in Chapter 4, which makes up one-half of the report, and examines the evidence of oscillatory motion in the two lakes. Records of temperature at municipal water intakes on both lakes occasionally show short bursts of oscillation, with a period of between 14 and 17.5 hours. The slow progression of a temperature "wave" northward past the intakes on the eastern shore of Lake Michigan after upwelling could be a Kelvin wave. Near shore the currents are predominantly shore-parallel and subject to rapid and frequent reversals associated with changes in the wind. Further offshore the rotational contributions of the Poincare waves assume greater importance and are often dominant. The final section demonstrates that, although a large part of internal wave energy in the Lakes is concentrated near the lower frequency limit corresponding to the dominant long wavelengths, shorter wavelengths are also conspicuous. Another concentration of wave energy occurs near a high frequency limit, called the Brunt-Vaisala frequency, corresponding in Lake Michigan to wave periods of a few minutes. Possible mechanisms for the transfer of wave energy from low to high, and high to low frequencies, are discussed. The most clearly established result in Chapter 4 is the demonstration of transverse standing wave patterns, dominated in one episode by the uninodal and in the other by a quintinodal component. A number of pieces of evidence combine to suggest that very long north-south wave lengths were present.

273. Murphy, T. E. 1970. Considered Lake Erie-Lake Ontario waterway. U. S. Army Corps of Engineers, Buffalo District. Technical Report H-70-3. 53 p.

The investigation reported herein was conducted to assist the U. S. Army Engineer District, Buffalo, in determination of the economic justification of a water route connecting Lake Erie and Lake Ontario. Specifically, the study involved determination of the most functional and economical location for a lock in the vicinity of Buffalo, N. Y. and evaluation of navigation conditions at the entrance to an overland canal joining the American channel of the Niagara River northwest of North Tonawanda, N. Y.

An existing model of the Niagara River with a horizontal scale of 1:360 and a verticle scale of 1:60 and a new understarted model of the canal entrance with a 1:120 scale were used in the investigation.

Tests demonstrated the desirability of placing the new lock in the vicinity of Buffalo as far downstream as is feasible without rendering the existing Black Rock Lock and Canal inoperable during the construction period. Navigation problems at the canal entrance were not as severe as had been contemplated and a small amount of overexcavation resulted in satisfactory conditions.

Murthy, C. R. - See: H. S. Weiler, No. 430.

274. Murthy, C. R. 1969. Large scale diffusion studies at Niagara River mouth, Lake Ontario. Proceedings 12th Conference Great Lakes Research. pp. 635-651.

Some results of large scale dye plume experiments conducted during the summer of 1968 at the mouth of the Niagara River are presented. Analysis of the results includes cross plume concentration data and certain diffusion characteristics of the dye plume at the river mouth. The results indicate a very rapid river mixing fairly close to the source, followed by fairly regular diffusion typical of a lake situation.

275. Murthy, C. R. 1970. An experimental study in horizontal diffusion in Lake Ontario. Proceedings 13th Conference Great Lakes Research. pp. 477-489.

During the 1969 field season, three dye patch diffusion experiments, in early May, mid June and late August, were conducted of the western end of Lake Ontario, as part of a coordinated program, known as MELON (Massive effort on Lake Ontario), to study large scale horizontal diffusion in the Great Lakes environment. In each experiment, a slug of water soluable rhodamine B dye in 40% acetic acid-methanol solution was introduced into the surface layer. The growth of the diffusing dye patch was followed at different times for about 60 hours after dye release using the familiar fluorometric technique. The data covered a length scale from 100 m to 10 km and the corresponding eddy diffusivities varied from 10^3 to 10^5 cm^2/sec. a diffusion characteristic prepared from the data suggests that the horizontal eddy diffusity grows as the 4/3 power of the length scale in accordance with the results of the similarity theory of turbulence.

276. Murthy, C. R. and G. T. Csandy. 1971. Outfall simulation experiment in Lake Ontario. Abstract of paper presented at the 14th Conference Great Lakes Research, Toronto, Ontario, April 19-21, 1971. p. 161.

In order to obtain some experimental evidence on diffusion, rhodamine dye (B) was released in Lake Ontario, near Oshawa, in water 20 m deep, 3 meters from the bottom, from 10 m long diffusion pipe arranged horizontally. The intention was to carry out surveys of the resulting plume for prolonged periods (10 days).

Vertical sections across the dye plume were regular. Horizontal distributions in contrast were many peaked, mostly very much wider than comparable dye plumes near the surface, and in some places consisted of only discrete patches of dye, hundreds of meters distant. These features of diffusion may be attributed to wave-like character of flow at low residual velocity.

277. Newberry, J. S. 1870. On the surface geology of the basin of the Great Lakes and the valley of the Mississippi. Annals Lyceum of Natural History. 9: 213-234.

Topographic and geologic data for the Great Lakes - Mississippi Valley areas are presented, including properties and structures, location, occurrence, formation, evolution and local characteristics.

278. Newberry, J. S. 1882. On the origin and drainage of the basins of the Great Lakes. Proceedings American Philosophical Society, Philadelphia. pp. 91-101.

A general discussion by the author of the origin and drainage of the basins of the Great Lakes is accompanied by an objective discussion of the glacial theories of erosion by Mr. Leslie. The topography, geology, drainage, age, evolution and characteristics of the basin are all discussed.

279. Newland, D. H. 1933. The Paleozoic stratigraphy of New York. International Geological Congress, 16th Session. Guidebook 4, Excursion A-4, Washington, D. C. 136 p.

A paper written for an excursion throughout New York State. Various distinct areas of geologic formations are separated and analyzed for geology, climatology, topography and stratigraphy.

280. New York State Atomic and Space Development Authority. Undated. A thermal profile of the waters of New York State. Albany, New York. 27 p.

The technique of infrared aerial scanning is utilized to ascertain surface water temperatures of Lake Ontario and many of the major waterways of New York State. The currents, winds and waves have various mixing and dispersion characteristics which can be followed easily by high altitude infrared scanning.

281. New York State Department of Health. 1957. Lake Ontario drainage basin series, Eighteen Mile drainage basin. NYS Department of Health, Albany, Report No. 3. 71 p.

A comprehensive biological, physical and chemical study of the Eighteenmile Creek Drainage Basin and other tributaries entering Lake Ontario between the NiagaraRiver and Eighteenmile Creek. The physical parameters from this NYS Health Department report include: temperature, precipitation, topographic maps, stream locations and flow direction, volume, variation and levels, water sources, industrial and domestic uses, classification of shoreline areas, water color, odor, turbidity and suspended matter, geological land formations, stream and lake sampling stations.

282. New York State Department of Health. 1958. Lake Ontario Drainage Basin Survey Series, Lake Ontario surface waters, including specified tributaries. NYS Department of Health, Albany, N. Y., Report No. 4. 447 p.

A comprehensive biological, physical and chemical study of Lake Ontario and its tributaries. The physical parameters include: temperature, precipitation, topographic maps, stream locations and flow, water sources, industrial and domestic uses, flow direction, volume, variation and water levels, classification of shoreline areas, water color, odor turbidity, suspended matter, geological land formations, stream and lake sampling stations.

283. New York State Department of Health. 1961. Lake Ontario Drainage Basin Series, Upper Genesee River drainage basin. NYS Department of Health, Albany, N. Y., Report No. 2. 219 p.

A comprehensive biological, physical and chemical study of the Upper Genesee River Drainage Basin. The physical parameters from this NYS Department of Health report include: temperature, precipitation, topographic maps, stream locations and flow direction, volume, variation and levels, water sources, industrial and domestic uses, classification of shoreline areas, water color, odor, turbidity and suspended matter, geological land formations, stream and land sampling stations.

Nunez, M. - See: J. A. Davies, No. 145.

284. O'Connor, D. J. 1959. Statistical analysis of drought flows of rivers of New York State. New York State Water Pollution Control Board Research, Albany, N. Y., Report No. 1. 61 p.

On many rivers in the state, flow gauging stations are maintained by the U. S. Geological Survey. These stations and the published records of stream flow gently assist in the conductance of the water pollution surveys and classifications. Statistical analysis of the low flows may be made, from which a drought of any severity may be estimated. This report proposes to:

1. present the cumulative frequency distributions of drought flows so that a low flow of any desired frequency may be determined directly.
2. determine which of the three commonly employed distributions is most appropriate for such analysis in order to establish a basis for future work.
3. generalize the major drainage basins or geophysical areas in the state.

Offield, T. W. - See: D. W. Fisher, No. 172.

285. Oliver, W. A., Jr. 1954. Stratigraphy of the Onondage limestone (Devonian) in Central New York. Bulletin Geological Society of America. 65: 621-652.

Detailed studies of the distribution of fossils in the Onondaga limestone (Devonian) in central New York permit division of the formation into four members each of which is subdivided into two or more zones and several lateral facies. The Edgecliff (lowest) member is a coral biostrome over much of the State but locally passes into a bioherm facies. A basal zone of reworked sand (Springvale of various authors) is included in the Edgecliff whereever present. The Nedrow member is a shaly limestone characterized by a variety of platyceratid gastropods. The upper part of the member is a more massive limestone with a sparse fauna. The Nedrow passes westward into cherty limestone with few fossils and wastward into coarse limestone. The Moorehouse member is a massive, fine-grained limestone characterized by abundant brachipods and certain large coiled cephalpods. This member passes west and east to coarser limestones with brachipod-coral founas. The base of the Seneca (upper) member is defined as the "Tioga bentonite," a prominent marker bed and an important paleontologic break. The Seneca is characterized by an abundance of *Chonetes lineatus* and a few other forms. The Seneca member passes to the east into the Union Springs black shale of the overlying Marcellus formation. This relationship is indicated by the eastward thinning of the limestone and thickening of the black shale unit, and by the eastward disappearance from the top down of the Seneca zones which are recognized in the type area.

286. Ontario Water Resources Commission. 1962. Report on a lakefront survey of water quality, waste outfalls, and drainage inlets of Lake Ontario within the area town of Burlington to Scarborough township, inclusive. Ontario Water Resources Commission, Toronto. 142 p.

Tabulated data are presented for Canada on the surface water of Lake Ontario along the shoreline from Burlington to Scarborough on: water temperature, suspended solids and turbidity. Descriptive statements are made for each sampling location. These statements include date and location of sampling and weather conditions. (Canada Centre for Inland Waters).

287. Ostry, R. C. 1971. Hydrology of the Forty Mile Creek drainage basin on the south shore of Lake Ontario. Abstract of paper presented at 14th Conference Great Lakes Research, Toronto, Ontario, April 19-21, 1971. pp. 170-171.

The forty mile creek drainage basin is considered to be typical of the ground water regime developed in the Niagara Peninsula area and has been studied as a part of the International Field Year on the Great Lakes program to assess the ground water contribution to Lake Ontario. The results of this hydrogeologic study are as follows:

1. The ground water divide to a depth of approximately 150 feet below the ground surface appears to be the same as the surface divide.
2. Two ground water flow systems were deliniated and have been designated as local and regional.
3. Ground water discharge from the regional system is influenced by the topographic relief associated with the Niagara escarpment.
4. Apparent velocities of ground water movement are 3000 feet per year in Silurian bedrock and approximately 100 feet per year in the underlying formations.
5. Water quality deteriorates rapidly across the basin from the divide to the stream channel and also with increasing depth.
6. Direct ground water discharge in the area per mile length of Lake Ontario is in the order of 6000 Igpd.

288. Owen, E. B. 1969. Stratigraphy and engineering description of the soils exposed on a section of the Welland Canal by-pass project (contract 743). Ontario, Canada Department of Energy, Mines and Resources. Geological Survey of Canada. Paper 69-31. 22 p.

The methods and procedures used to forcase excavation requirements in the Welland Canal by-pass project are outlined. Comparison is made between geological conditions inferred before excavation and the conditions actually encountered by the contractor.

289. Pach, A. B. 1963. The heavy snows at Watertown, N. Y. Weatherwise. 16(2): 66-67, 78.

The winter of 1962-1963 had an abnormally heavy snowfall, snow cover, and persistently cold temperatures (January average was below 3°F - February average below 8°F) near Watertown, New York. The snow caused economic problems and the weight of the snow mass collapsed several roofs. The article includes a general accumulation discussion, but no explanation.

Pade, B. - See: G. T. Csandy, No. 142, 143.

Paine, D. A. - See: J. E. Jiusto, No. 225.

290. Palmer. M. D. 1968. Currents in Frenchman Bay area of Lake Ontario. Ontario Water Resources Commission, Toronto, Ontario. Unnumbered.

Two recording current meters were operated from June to August, 1968 in 12.7 m (42 feet) of water at distances of 2.42 m (8 feet) and 4.6 m (15 feet) from the bottom approximately 1.6 km (1 mile) offshore in the Frenchman Bay area of Lake Ontario. A time series analysis was carried out on the resulting data for the various months. A maximum current of 21 cm/sec. (0.69 fps) observed was significantly lower than results obtained by similar current meter studies in adjacent areas and farther offshore. This appears to be a result of the shore geometry which reduced the currents in the area. Both the directions and persistence factors agree with results of other studies. Wind does not appear to be directly responsible for currents in the area which are produced as a result of diurnal, inertial and Lake Ontario free oscillation effects. The thermal regimes were a direct consequence of inertial effects. (Canada Centre for Inland Waters).

291. Palmer, M. D. 1969. Simulated thermal effluent into Lake Ontario. Proceedings 12th Conference Great Lakes Research. pp. 674-485.

The dispersion pattern of Duffin Creek water into Lake Ontario was determined under two different wind conditions in the spring time when the flow was used to trace the plume by continuous dye injection. The flow was 180 cfs and the water was 5°F warmer than the lake water. Based upon experimental results, a model was developed which predicts maximum concentrations within 25% for distance up to 4000 feet from source. Maximum dye concentrations varied as the (distance) -0.8. The model applied to an existing thermal generating station at Lakeview was capable of predicting maximum temperatures within 25% of measured values.

292. Palmer, M. D. 1971. Estimate of the physical extent of thermal plumes at Lakeview, 1971. Ontario Water Resources Commission, Toronto. 31 p.

The cooling plumes from an operation thermal electric generation plant station at Lakeview, west of Toronto, on Lake Ontario, were defined by water temperature measurements. The generating station discharged between 1400 to 2500 cfs of cooling water at 15°F. above intake water temperatures. The temperature measurements were made throughout the year at various depths in proximity of the discharge to define the physical cooling water plume in the lake. Equations were developed which defined plume area as a function of distance from the discharge, temperature as a function of plume area and plume centreline as a function of wind. Different relationships were developed for summer and winter conditions based upon the ambient lake temperature. The most significant cooling resulted from mixing with lake water. (Canada Centre for Inland Waters).

293. Palmer, M. D. and J. B. Izatt. 1970. Lakeshore two dimensional dispersion. Proceedings 13th Conference Great Lakes Research. pp. 495-507.

Hourly two dimensional dispersion characteristics are determined from recording current meter histories for the nearshore areas of Lakes Erie and Ontario. The current histories were obtained in areas within 4 km of shore and at water depths of 10-14 m during May to December, 1968. A markov chain process was applied to hourly current readings. Three different formulations of the stochastic process were tested prior to the selection of the most reliable one. The results obtained in applying the developed technique were compared favorably with the results obtained form conventional dye injection and drogue studies.

294. Paskausky, D. F. 1971. Winter circulation in Lake Ontario. Abstract of paper presented at 14th Conference, Great Lakes Research, Toronto, April 19-21, 1971. pp. 21-22.

In winter, Lake Ontario is in a barotropic or homogeneous fluid circulation mode. A barotropic, prognostic, numerical circulation model, which includes topographic, inertial, lateral and bottom friction and wind stress terms, is applied to Lake Ontario. The circulation pattern is determined for two cases; first, the river inflow and outflow only and second with both river flow and wind field that could be produced by a meteorological high pressure area to the southeast of the Lake.

Pentland, R. L. - See: E. Magorian, No. 268.

295. Pentland, R. L. 1968. Hydrologic statistics and lake level regulation. Abstract of paper presented 11th Conference Great Lakes Research, Univ. of Wisconsin, Milwaukee, Wisconsin. p. 36.

Maps showing the distribution of runoff are presented for the entire Great Lakes Basin on a monthly and annual basis. Computerized methods have made possible the utilization of more than 250 hydrometric stations within and surrounding the basin for each of the thirteen runoff maps. A geographical representation of the area-runoff distribution for the subbasin is also presented. The paper includes a general discussion of the effects of climatological and physical features in relation to the runoff characteristics.

296. Pentland, R. L. and N. E. Eryuzlu. 1969. A dynamic programming algorithm for the operation of the Great Lakes. Department of Energy, Mines and Resources, Inland Waters Branch. Reprint Series No. 53. 24 p.

In Great Lakes regulation studies currently being conducted by the International Joint Commission, the economic consequences of many regulation plans are being evaluated by various agencies who have a direct interest in the outcome of the studies. A wealth of economic data has been gathered which enables the determination of benefits or detriments of any given plan of regulation in each particular interest for each lake and for each country (Canada and the United States). A dynamic programming algorithm is used to facilitate the development of operating policies. A number of short cuts and approximations are required due to the magnitude of the investigation. The scope of the problem is discussed along with some of the methods used to reduce computing costs to reasonable proportions.

Peterson, C. P. - See: R. L. Drake. No. 162.

297. Phillips, D. W. 1971. The modification of surface air over Lake Ontario in water. Abstract of paper presented at 14th Conference Great Lakes Research, Toronto, Ontario, April 19-21, 1971. p. 60.

Climatological and synoptic studies of the Great Lakes and their basins have always suffered from a scarcity of data over the lakes. This is especially true of the winter months from December to April when a few ships move out of port. This study provides a method of estimating the extent to which surface temperatures and humidities are modified in passing over Lake Ontario during the cold months. Temperatures, cloud height and amount, wind direction and speed, and air pressure were measured. The difference between the air temperature on land and water temperature of the sample site at the ship was used as an index of stability and the over water fetch was measured. An index of "time over water" was computed by combining the fetch distance and wind speed.

298. Pincus, J. H. 1959. Great Lakes basin. American Association Advancement of Science, Washington, D. C. Publication No. 71. 308 p.

An extensive book produced by the combination of many articles by different authors pertaining to the various aspects of the Great Lakes Basin. The following articles pertaining to physical characteristics are presented.

Geologic Framework - J. L. Hough
Drainage and Climate - W. E. Powers
Water Balance of the Great Lakes System - J. P. Bruce
Great Lakes Waters, Their Circulation and Physical and Chemical Characteristics - J. C. Ayers
Regimen of the Great Lakes and Fluctuations of Lake Levels - W. T. Laidly
Recession of Great Lakes Shorelines - H. J. Pincus
Surface and Groundwater Supplies in Ontario - A. K. Watt
Water Pollution in the Great Lakes - A. H. Dahl
Great Lakes Water Supply - The Years Ahead - H. W. Posten

(Canada Centre for Inland Waters).

299. Pohlman, J. 1884. The life history of the Niagara River. Proceedings American Association Advancement of Science, 32d Meeting. p. 203.

Lakes Erie and Ontario once stood at the same height at one time (that of Lewiston Heights). As Lake Ontario drained, the channel from the whirlpool to Lewiston was easily eroded. The channel of the river above the whirlpool was part of the old river flowing between the two lakes but was bottled up by the last glacier. Therefore, the age determinations of the glacial retreat versus erosion time are always too great because the erosion distance was not from Lewiston to the present site of the falls at Niagara.

300. Pohlman, J. 1887. The Niagara Gorge. Abstract of paper presented in the Proceedings American Association Advancement of Science, 35th Meeting. pp. 221-222.

The Niagara Groge was cut originally by three separate falls. The lower (downstream) two having softer sandstones to erode, receeded at a much faster rate eventually catching the upper falls which was eroding harder limestone and receeding slower. The St. David Gorge was bottled up by the last ice retreat forcing the river to flow down a channel previously flowing into the river at the present whirlpool site.

301. Pound, A. 1945. The American Great Lakes series - Lake Ontario. Bobbs-Merrill Co. Publishers, Indianapolis, Indiana. p. 235-345.

A historical survey of the Lake written in lay terms including Indian history and wars.

Part 3 contains data on counties, cities and industries along the lake shore. It also includes some data of history of Niagara Falls and prominent landmarks.

302. Powers, C. and A. Robertson. 1966. The aging Great Lakes. Scientific American. 215(5): 3-10.

Aging process increases are discussed in relationship to eutrophication and siltation. Lake Ontario has increased in dissolved solids in the last 50 years approximately 50 ppm.

303. Prichard-Carpenter. Undated. Drift and dispersion characteristics of Lake Ontario nearshore waters, Rochester, New York to Sodus Bay, New York. Rochester Gas and Electric Corporation, Rochester, N. Y. 23 p.

Drift and dispersion studies were conducted in Lake Ontario during April-May, July and October, 1965. The study area was along the south shore of the lake between Rochester and Sodus Point. The drift was found to be primarily wind induced, with speeds and direction. A steady drift to the east of 0.05 knots was present during calm periods.

Tracer material was released continuously at the Brookwood site during the study periods. The observed distributions of released material were fitted to theoretical equations. The probable distributions of heat and material released with the condenser cooling water flow under different discharge structure designs were computed from the observed diffusion data. These computations show that the use of a horizontal jet minimized the thermal effect and produced the most rapid dilution of constituents, so that a jet (approximately 2 ft/sec) discharge should be considered as optimum. With horizontal discharge, significant heating would not be present along the lake shore beyond the site boundary and the area with temperatures elevated by 5 degrees would extend out into the lake approximately 3000 feet and have an average width of 200 feet.

The study showed that a twenty-fold or greater dilution would occur before the discharge reaches the area of the nearest public water intake (town of Ontario). This intake is located on the bottom at a depth of 11 feet. Thirty-fold dilution would be expected before the discharge could be drawn into the plant intake located on the bottom at a depth of 28 feet. (Canada Centre for Inland Waters).

Putnam, D. F. - See: L. J. Chapman, No. 96, 97, 98, 99.

304. Radforth, I. 1941. Some considerations on the distribution of fishes in Ontario. M. A. Thesis, Department of Zoology, Univ. of Toronto. 119 p.

Included is a section on the geologic history of the principal drainage systems of Ontario. Glacial retreats and the formation of the Great Lakes are both discussed. (Univ. of Toronto, Zoology Library).

305. Rafter, G. W. 1905. Hydrology of the State of New York. New York State Museum Bulletin 85. 902 p.

Data are given for all major lakes and river systems in New York State. Meteorological data are given on a yearly basis and include: temperature, pressure, humidity, precipitation and wind velocity. Mean air temperature and precipitation are discussed on a monthly basis also. Each water system is isolated and analyzed for topography, geology, volume flow, flow characteristics and drainage area.

306. Rainey, R. H. 1967. Natural displacement of pollution from the Great Lakes. Science. 155(3767): 1242-1243.

A simplified mathematical model of a lake system indicates that, if the pollution of the Great Lakes were discontinued, the natural flow through the lower Great Lakes would be sufficient to remove about 90 percent of the waste in about 20 years. On the other hand, hundreds of years would be required to displace the pollution from Lake Michigan and Lake Superior.

307. Rao, G. V. 1971. A numerical analysis of a potential snow squall situation over Lake Ontario with a primitive equation model. Abstract of paper presented at the 14th Conference Great Lakes Research, Toronto, Ontario, April 19-21, 1971. p. 63-64.

The purpose of this diagnostic study is to provide on a preliminary basis the three-dimensional structure of a potential snow squall saturation with the aid of a consistent system of dynamical equations and approximations. Wind and geopotential heights were plotted on a large area base map covering most of North America. Geopotential, isotach and streamline analyses were subjectively performed. The analyses over Lake Ontario then were transferred to a local area base map. The initial fields of motion and temperature over the local area were calculated following the procedures sketched by earlier investigators.

308. Repp, R. D. 1970. Ailing Niagara Falls. Water Spectrum. 1(2): 32-38.

Discussion of the study conducted by the Army Corps of Engineers of the American section of Niagara Falls. A cofferdam was constructed at the southern end of Goat Island blocking the American Channel. The Corps was then able to undertake a geological investigation of Falls materials and erosion. Faulting and stresses were measured by borings and electronic sensing equipment.

309. Richards, T. L. 1963a. The meteorological factors affecting Great Lakes water levels. Canadian Department of Transport, Meteorological Branch. Circular 4182, Tec. 553, Toronto. 22 p.

The Great Lakes are subject to large and varied fluctuations in water levels. Most of these are due to meteorological factors; - wind and pressure are responsible for short-term variations, precipitation and evaporation for annual and longer-term changes.

Man-made alterations, such as diversions and channel deepenings, have resulted in lake level changes that are small compared to those caused by meteorological factors except in Lake Huron/Michigan where a significant downward trend since 1880 is apparent. (Univ. of Toronto, Great Lakes Institute.

310. Richards, T. L. 1963b. Meteorological factors affecting ice cover on the Great Lakes. Great Lakes Research Division, Univ. of Michigan. Publication 10: 204-215.

Freezing and thawing degree day data from a 14 year record were used to calculate average and extreme ice conditions that may be expected from the lake. The depth of the lake has a direct effect on the formation, retention and dissipation of ice cover and in the case of a deeper lake (such as Lake Ontario), will actually reduce ice cover. Reduction of ice cover is a much more rapid process than the formation of ice and requires a much smaller change in temperature.

311. Richards, T. L. 1964. Recent developments in the field of Great Lakes evaporation. Verh. Internat. Verein. Limnol. 15: 247-256.

The research program of the Great Lakes Institute's research ship is described including, the limnological and meteorological parameters measured and the processing of data. Evaporation over the Great Lakes was studied. Micro-profiles of data obtained by the ship's meteorological boom are being assessed although this method of obtaining data has limitations. Data were also collected to establish lake-land ratios for Humidity Ratio H and Wind Ratio R. These ratios permit climatological data from shore stations to be adjusted to make monthly lake evaporation estimates using the Mass Transfer Method. Evaporation figures for Lake Ontario were calculated this way and comparisons are made with other methods. Suggestions for refining the ratios are made.

312. Richards, T. L. 1969. The Great Lakes and the weather. Great Lakes Institute, Univ. of Toronto. PR-39. p. 10.

The subject of the Great Lakes and the weather is a very broad one and indeed includes much more than might be apparent at first glance. That the almost 100,000 square miles of water surface making up the system has a powerful influence on the weather may be confirmed by any one of the 50 million inhabitants living in the region. However, at least as important is the fact that individual weather elements also have a tremendous influence on the Lakes themselves, i.e. winds cause waves and shore damage, currents affect the distribution and dispersal of pollutants, freezing temperatures bring ice and an end to navigation and precipitation and evaporation combine to cause very large and economically important variations in water levels. As a result, this review will consider both aspects of the interaction between the Great Lakes and the weather. (Canada Centre for Inland Waters).

313. Richards, T. L., H. Dragert and D. R. McIntyre. 1966. Influence of atmospheric stability and over-water fetch on winds over the lower Great Lakes. Monthly Weather Rev. 94(7): 448-453.

Five years of wind observations taken by the research vessel C.C.G.S. Porte Dauphine on Lake Erie and Lake Ontario have been compared to simultaneous observations taken at land stations upwind of the ship. The resultant ratios of over-lake winds/over-land winds have been sorted by speed classes, conditions of atmospheric stability and the length of the over-water fetch to assess the relative influence on each factor on the over-lake wind.

The effect of changes in atmospheric stability as created by air-water temperature differences is shown quantitatively with results confirming that wind speeds increase over water during unstable conditions and decrease during stable conditions. It is also shown that these changes are greatest in low winds and least in high winds.

An increase in the length of the over-water fetch up to about 25 mi. contributes to an increase in wind speeds during unstable conditions. Under very stable conditions the lake winds become lighter with longer fetches but the changes are highly erratic. This is likely due to intermittent breakdowns of the shallow atmospheric inversion layer associated with the stable conditions. An increase in fetch beyond 25 mi. does not appear to contribute to any further change in speeds.

314. Richards, T. L. and J. P. Fortin. 1962. An evaluation of the lake-land vapor pressure relationship for the Great Lakes. Great Lakes Research Division, Univ. of Michigan. Publication 9, pp. 103-110.

Several methods have been used in recent years for the quantitative determination of evaporation from a large body of water. One classic approach is the Mass Transfer Method involving a water vapor flow formula. 705 synoptic hour observations were used from Lakes Ontario, Erie, Superior and Huron to help redevelop the equation and modify it to fit the size of the Great Lakes basin.

315. Richards, T. L., J. G. Irbe and D. G. Massey. 1969. Aerial surveys of Great Lakes water temperature, April 1966-March 1968. Canada Department of Transport, Meteorological Branch, Climatological Studies. No. 14. 55 p.

Extensive aerial survey data are presented on all the Great Lakes from a series of 82 ART surveys. Depth, temperature gradients, surface temperatures, mixing and diffusion studies are discussed and shown in maps of the Great Lakes.

316. Richards, T. L. and P. Loewen. 1955. A preliminary investigation of solar radiation over the Great Lakes as compared to adjacent land areas. Great Lakes Research Division, Univ. of Michigan. Publication 15, pp. 278-281.

This preliminary investigation includes observations from sectors of Lakes Ontario, Erie, Huron, and Superior within 100 miles of Sault Ste. Marie, Cleveland and Toronto during the months of April to December inclusive and presents the comparisons as monthly ratios of total radiation over water to total radiation over land. Results based on data collected since 1960 confirm the physical concept of substantially greater incoming solar radiation over the lakes during the summer (due to less cloud cover over the water areas) with the opposite effect particularly evident in the early spring and late fall.

317. Richards, T. L. and G. K. Rodgers. 1964. An investigation of the extremes of annual and monthly evaporation from Lake Ontario. Great Lakes Research Division, Univ. of Michigan. Publication 11, pp. 283-293.

The modified mass transfer method, provides a useful technique for examining evaporation from a large lake. In this particular study a number of contributions have been made towards a better understanding of the evaporation process as it concerns Lake Ontairo:

(a) A method has been developed to translate daily water intake temperatures into realistic mean monthly surface water temperatures.

(b) Average evaporation estimates for Lake Ontario have been calculated for the 14-year period 1950-1963, confirming previously reported characteristics of the annual evaporation cycle.

(c) Evaporation estimates have been calculated on a month to month basis over a 14-year period. The maximum, minimum and standard deviations of these estimates produce an indication of the variability of evaporation from Lake Ontario not previously available.

(d) A direct comparison of month to month averages of wind speed, vapour pressure and surface water temperatures with evaporation estimates for the same months points up the relative importance of these meteorological parameters in the evaporative process. As noted earlier, better evaporation estimates will come from a better understanding of the lake and the atmosphere above it, assisted by the continued acquisition of data - be it by research vessels, lake towers, networks of buoys or aircraft observations.

Rickard, Lawrence V. - See: J. G. Broughton, No. 39.

Rickard, L. V. - See: D. W. Fisher, No. 172.

318. Rickard, L. V. 1964. Correlation of the devonian rocks in New York State. NYS Museum and Science Service Geological Survey. Map and Chart Series No. 4. 1 sheet.

Contains a large map and accompanying tables of the devonian rocks in New York State. The various geological eras are discussed along with geology, stratigraphy, evolution, erosion and topography.

Robertson, A. - See: C. Powers, No. 302.

Robinson, P. J. - See: J. A. Davies, No. 145.

Robison, F. L. - See: P. E. Greeson, No. 192.

319. Robison, F. L. 1969a. Floods in New York-1967. U. S. Geological Survey Report Of Investigations RI-3, Albany, New York. 32 p.

This report presents information on floods reported in NYS during the calender year of 1967. Special emphasis is placed on cause, date, location, volume discharge accidents and damage caused by flooding.

320. Robison, F. L. 1969b. Floods in New York-1968. U. S. Geological Survey Report of Investigation RI-9, Albany, New York. 30 p.

This report presents information on floods reported in NYS dueing the calendar year of 1968. Special emphasis is placed on cause, date, location,volume discharge, accidents and damage caused by flooding.

321. Rockwell, D. C. 1966. Theoretical free oscillations of the Great Lakes. Great Lakes Research Division, Univ. of Michigan. Publication 15, pp. 352-369.

The lowest five modes of longitudnal free oscillation of each of the Great Lakes are investigated by numerical intergration of the hydrodynamical channel equations. The corresponding periods, surface profiles and volume transports are presented and discussed. The fundamental periods are: Lake Superior-7.2 hrs; Lakes Michigan/Huron-47.8 hrs; Lake Michigan-8.8 hrs; Lake Huron-6.5 hrs; Lake Erie-14.1 hrs; and Lake Ontario 4.9 hrs. Special consideration is given to Lakes Michigan and Huron in connecting these lakes through the Straits of Mackinac.

Rodgers, C. W. - See: G. E. McVehil, No. 266.

Rodgers, G. K. - See: D. V. Anderson, No. 11, 14.

Rodgers, G. K. - See: J. P. Bruce, No. 43, 44.

Rodgers, G. K. - See: P. F. Hamblin, No. 200.

Rodgers, G. K. - See: T. L. Rickards, No. 317.

Rodgers, G. K. - See: W. G. Simpson, No. 351.

322. Rodgers, G. K. 1959. Temperatures and currents near shore in the Longbunch-Port Credit area. Ontario Dept. of Lands and Forests, Physics Research Note No. 7: 3. 4 figures.

This article covers the following topics:

(a) Surface temperature - surface temperatures measured in 1958 on the long branch shoreline never exceeded 70°F. To allow approximate extrapolation to toher seasons the temperature of water coming in the Slow Sand Intake of the Toronto Island, Toronto Water Works plant is plotted in Figure 4. This intake is at a depth of about 40 feet. Of special note is the frequent intrusion of cold water at this depth during the summer months.

(b) Temperature structure - water along this shoreline is stratified in the summer. There was always a nearly homogeneous upper layer (homogenous in temperature) of at least 20 feet in depth during July and August. This homogenous layer (epillimnion) is shallower than most of the open lake. Below this layer, in the thermocline, the temperature decreased with gradients ranging from two to 10 F degrees in about 10 feet. Thus, during July and August the water at 40 feet was five to ten degrees colder than surface water.

In the fall, stratification was much less marked and the water more nearly homogeneous in tempearture. Thus, while surface temperatures were relatively well maintained at a summer level, temperatures at 40 feet were more nearly equal to surface temperatures and hence temperatures at 40 feet were often higher in September than during July and August.

(c) Surface currents - currents measured in the surface on 27 November were in the same direction as the wind, and the exception is that surface currents are determined by the wind in this area. The surface currents in lakes are principally wind controlled is a fact confirmed by many observers (Hutchinson, 1957).

The Climatological Atlas of Canada indicates that principal wind directions in winter at Toronto are W, SW, NW and N. In summer, winds are evenly distributed around the compass with the exception of a lower frequency of winds from the SE. Thus, average surface littoral currents throughout the year should, in this area, tend to flow easterly, although the evidence is by no means conclusive. (Univ. of Toronto, Zoology Library).

323. Rodgers, G. K. 1962. Lake Ontario data report. Great Lakes Institute, Univ. of Toronto. PR-7. 102 p.

This publication contains limnological and meterological data collected annually by the Great Lakes Institute. Information contained in the report includes the following parameters in the following categories.

1. Meteorology - wind velocity and direction, temperature, humidity, clouds, waves.
2. Radiation data.
3. Limnology data - surface temperature, waves, turbidity, gradients, conductivity.
4. Bathythermography traces.

324. Rodgers, G. K. 1963. Lake Ontario data report. Great Lakes Institute, Univ. of Toronto. PR-10. 192 p.

This publication contains limnological and meterological data collected annually by the Great Lakes Institute. Information contained in the report includes the following parameters in the following categories.

1. Meteorology - wind velocity and direction, temperature, humidity, clouds, waves.
2. Radiation data
3. Limnological Data - surface temperature, waves, turbidity, color, temperature gradients.
4. Bathythermograph traces.

325. Rodgers, G. K. 1966a. A note of the thermocline development and the thermal bar in Lake Ontario. Symposium of Garda, International Association Scientific Hydrology. 1(70):401-405.

Lakewide temperature observations in Lake Ontario have been made during the spring when the thermocline is forming and the thermal bar is present in the lake. Examination of heat content changes in the central, deepest parts of the lake reveals that advection of warm surface water from areas nearer shore plays a significant role in the development of the major thermal stratification in these deeper areas once the thermal bar has passed. Waters formed in the thermal bar become summer hypolimnion.

326. Rodgers, G. K. 1966b. The thermal bar in Lake Ontario, spring 1965 and winter 1965-66. Great Lakes Research Division, Univ. of Michigan. Publication 15, pp. 369-374.

The temperature and water masses of Lake Ontario were studied during the spring and winter periods when waters are present at temperatures both above and below the temperature of maximum density. The zone where the surface was just at the temperature of maximum density (the thermal bar) separating these waters demonstrated marked horizontal gradients in temperature, turbidity and color. The movement of the thermal bar is documented for the spring condition and current measurements taken in the bar are shown.

327. Rodgers, G. K. 1968. Heat advection within Lake Ontario in spring and surface water transparency associated with the thermal bar. Proceedings 11th Conference Great Lakes Research. pp. 481-486.

The pattern of heat content changes throughout Lake Ontario during the period in which stratification developed (April through June) in the spring of 1965 suggests that advection of warm water from shore areas is an important factor in the formation of the thermocline on the shore side of the thermocline.

Previous papers on the thermal bar have described the high correlation of turbidity with temperature at the lake surface in the region of the 4° isotherm, based on visual reports. Records of crossing this isotherm in 1967 with a towed transmissometer thermometer confirm the correlation quantitatively and also reveal in detail the associated variety of horizontal temperature gradients.

328. Rodgers, G. K. and D. V. Anderson. 1961. A preliminary study of the energy budget of Lake Ontario. Journal of Fisheries Research Board of Canada. 18(4): 617-636.

Recent bathythermographic surveys carried out on the research vessle *Porte Dauphine* have provided estimates of heat content for Lake ontario and permitted a preliminary study of its energy budget. The imbalance between the absorbed short wavelength sun and sky radiation, and the loses due to evaporation, sensible heat conduction and net long wave length back radiation result in heating of lake water from March to August and cooling from September or October to February. The peak heat content lags the peak surface temperature by about one month. The amount of energy advected into the lake is relatively small compared with other terms in the evergy budget. Thus, energy budget calculations do not depend upon the accuracy with which the water budget is known.

The principal difficulty in applying present techniques for determination of an energy budget is lack of meteorological data over the lake surface.

329. Rodgers, G. K. and D. V. Anderson. 1963. The thermal structure of Lake Ontario. Great Lakes Research Division, Univ. of Michigan, Publication 10. pp. 59-70.

A lakewide survey of Lake Ontario is discussed indicating seasonal changes in layering and all over energy dynamics. The total energy of the lake follows a lag pattern behind the temperature changes over the various seasons.

330. Rodgers, G. K. and A. H. Lee. 1971. Temperature inversions in Lake Ontario. Abstract of paper presented at 14th Conference Great Lakes Research, Toronto. April 19-21. pp. 212-214.

For a temperate dimictic lake such as Lake Ontario, a temperature inversion refers to either an increase or decrease of water temperature with depth for waters near 4°C, such that in the absence of pressure effects, the temperature variation with depth would result in a state of static instability.

Parameters discussed are: frequency of occurrance, magnitude of the inversion, thickness of the inversion layer, depth of the temperature maximum or minimum, regional distribution, seasonal distribution and verticle and horizontal stabilities.

331. Rodgers, G. K. and G. K. Sato. 1970. Factors effecting the progress of the thermal bar of spring in Lake Ontario. Proceedings 13th Conference Great Lakes Research. pp. 943-950.

Evidence is presented supporting the contention that the primary control of thermal bar movement lies with surface heating and the initial heat content of the "cold" section of the lake into which the thermal bar moves.

In a discussion of what constitutes the beginning of the thermal bar, two regimes are identified. The first is the progress in the development of the thermocline in the whole lake, and is controlled primarily by surface heating and initial lake temperatures in the deep part of the lake. The second type of thermal bar arises due to flow of waters greater than 4°C into the lake at temperatures less than 4°C.

332. Rodgers, H. D. 1835. On the falls of Niagara and some authors opinions respecting them. American Journal of Science and Arts. 27: 326-333.

A basic discussion of the falls at Niagara is presented involving location, dimensions, viewpoints, general river characteristics, basic geology, evolution and age.

Rondy, D. R. - See: R. Wilshaw, No. 435.

333. Rondy, D. R. 1966. Great Lakes ice cover - winter 1965-66. U. S. Lake Survey, Army Corps of Engineers, Detroit, Michigan. Report 5-2, 44 p.

This report represents the 22 ice charts obtained by the U. S. Lake Survey observers on 12 ice reconnaissance flights. Made during the 1965-66 ice season. These flights covered a distance of about 9,775 statute miles and all ice-covered areas of the Great Lakes were observed. Maximum ice cover for each of the lakes occurred during the last two weeks in February. Estimates were: Lake Superior - 60%, Lake Michigan - 15%, Lake Huron - 20%, Lake Erie - 85% and Lake Ontario - 10%. During most of the winter 1965-66 a general northwestward shift of the storm tracks and blocking conditions created by pressure systems to the north contained the southern movement of the artic air mass. These blocking conditions caused air temperatures to be above normal in the Great Lakes area and contributed to a shorter than expected period of ice cover. (Canada Centre for Inland Waters.)

334. Rondy, D. R. 1967. Great Lakes ice cover - winter 1966-67. U. S. Lake Survey, Army Corps of Engineers, Detroit, Michigan. Report 5-3, 54 p.

Eighteen flights were made over areas of the Great Lakes to record ice conditions during the 1966-67 winter. Data collected on these flights are presented on forty ice charts.

Weather conditions over the Great Lakes in general during the winter of 1966-67 were characterized by frequent fluctuations of temperatures that averaged near normal.

Ice was first reported forming on Lake Superior during the last week of November and on Lake Erie during the last week of December. The maximum ice cover was observed during the first week in March on Lake Erie and the third week of March on Lake Superior. During the period of maximum ice cover Lake Superior was estimated to be 88 percent covered with the ice varying from heavy winter ice in the Duluth, Port Arthur and Whitefish Bay areas to 9/10 concentration of brash and floes in mid-lake; Lake Michigan, 46 percent covered with heavy winter ice in Green Bay and that area to the north and east of Beaver Island and various concentrations of brash and cake along the southern perimeter; Lake Huron 80 percent covered with heavy winter ice in the North Channel, Straits of Mackinac and Saginaw Bay; while the central basin was almost ice free all season; Lake Erie 85 percent covered with heavy winter ice in the form of consolidated brash and cake in the eastern and western basin; and Lake Ontario 12 percent; here the ice cover was confined to the eastern end and approaches to the St. Lawrence River. Ice was reported on Lake Superior as late as 16 April while on the same date the other lakes were comparatively ice free (Canada Centre for Inland Waters).

335. Rondy, D. R. 1968. Great Lakes ice cover - winter 1967-68. U. S. Lake Survey, Army Corps of Engineers, Detroit, Michigan. Report 5-4, 10 p.

Thirty-eight ice charts were produced from data collected on 14 reconnaissance flights made during the 1967-68 winter season.

Ice was reported forming in the Duluth, Minnesota area of Lake Superior as early as 12 November and on Lake Erie along the western shore as early as 16 November. During the period of maximum ice cover Lake Superior was estimated to be 90% ice covered with approximately equal areas of winter and young ice; Lake Michigan 30 percent ice covered with most of the ice concentrated in Green Bay and the island area in the north end of the lake; Lake Huron 50 percent covered with winter ice in the North Channel, Georgian and Saginaw Bay areas; Lake Erie 98 percent covered with young and winter ice. The eastern basin and the approaches to Buffalo Harbor contained large jammed areas with many windraws. Lake Ontario 10 percent, with the ice confined in general to the various channels to the northeast. In May ice was still being reported in the Black Bay area along the north shore of Lake Superior and on the Buffalo area of Lake Erie as late as 3 May.

336. Rondy, D. R. 1969a. Great Lakes ice atlas. Great Lakes Research Center, Army Corps of Engineers, Detroit, Michigan. 6 p. + 35 charts and tables.

A short article with extensive mapping on the accumulation, composition, properties of and dissipation of ice on the Great Lakes. The great depth and small surface area of Lake Ontario produce conditions unfavorable for ice formation because the central deep water mass resists extreme thermal changes and usually does not reach the freezing point. If ice does appear, it is quickly dissipated by winds. The ice cover extent is; 8% mild winter, 15% in a normal winter, and 25% on a severe winter. (Canada Centre for Inland Waters).

337. Rondy, D. R. 1969b. Great Lakes ice cover - winter 1962-63. U. S. Lake Survey, Army Corps of Engineers, Detroit, Michigan. Report 5-5, 33 p.

Eleven flights were made over areas on the Great Lakes during the winter 1962-63 resulting in the publication of fourteen ice charts. During the winter 1963-64, seventeen ice charts were produced from ten flights.

The U. S. Weather Bureau rated the winter of 1962-63 as one of the most severe in 100 years with temperatures across the Great Lakes region as much as 8°F below normal. By comparison, the winter of 1963-64 was warmer with temperatures averaging 2°F below normal in the south and 3°F above normal in the north. The temperature deviations from the normal for the winters of 1962-63 and 1963-64 are indicated by graphs of .2 freezing degrees-days for each of the lakes.

The ice cover on the lakes varied considerably during these two winters. Lake Superior had the greatest variation in ice cover with a difference of 64 percent in aerial extent between the winters of 1962-63 and 1963-64. Maximum ice cover.

Rukavina, N. A. - See: R. G. Sutton, No. 374, 375.

Rukavina, N. A. - See: D. L. Woodrow, No. 436.

338. Rukavina, N. A. 1967. Rapid inspection of soft sediment cored by x-radiography. Proceedings 10th Conference Great Lakes Research. pp. 143-148.

X-radiography provides a fast and non-destructive method for the preliminary inspection of unconsolidated sediment cores. Test radiographs of several cores from Lake

Ontario indicate that adequate definition of sedimentary structure is obtained when cores are radiographed in their plastic liners. This approach permits soft sediment structure to be recorded before it is distorted or destroyed by extrusion, and eliminates the conventional sample preparation for radiography. Preliminary results of a comparison of radiography density with sediment parameters indicate that density is a function of water content (porosity), which is in turn related to particle size, organic content and consistency.

339. Rukavina, N. A. 1969. Nearshore sediment survey of western Lake Ontario, methods and preliminary results. Proceedings 12th Conference Great Lakes Research. pp. 317-324.

Surface sediment samples, echo sounder profiles, and bottom observations by divers and with underwater television are being used to map the sediments and bottom morphology of nearshore Lake Ontario (depth 0-20 m). In 1968 mapping was completed in the western end of the Lake from Niagara on the south shore to Whitby on the north shore.

Six bottom types have been recognized and deliniated: 1) bedrock-23%, 2) glacial drift-39% and the recent sediments, 3) gravel and pebbly sand-9%, 4) sand-12%, 5) silt-sand-10%, 6) silt-clay-7%.

Recent sediments occur: 1) on the south shore from Niagara to Jordan, 2) on the west shore opposite the Burlington Bar, 3) on the south shore opposite metropolitan Toronto. The deposits at Toronto and Niagara result from local erosion shore bluffs; westward moving longshore currents supply the sediment accumulating offshore from the Burlington Bar.

340. Rukavina, N. A. 1970. Lake Ontario nearshore sediments Whitby to Wellington, Ontario. Proceedings 13th Conference Great Lakes Research. pp. 266-273.

Mapping was based upon bottom samples, echo sounder records and underwater television observations.

Three bottom types were identified and deliniated: 1) glacial sediment and lag deposit 55%, 2) sand 25%, 3) bedrock 20%. Glacial material occupies the major portion of the zone west of Colborne. Bedrock is exposed east of Colborne. The major sand deposit occurs in the area surrounding the Presquile Peninsula. Elsewhere the sand is restricted to the vicinity of creek mouths or entrances. Sand is contributed to the zone by stream discharge, bluff erosion and submarine erosion. Net transport is in an eastward direction and accumulation occurs in the vicinity of Presquile.

341. Sanderson, M. 1971. Variability of annual runoff in the Lake Ontario basin. Abstract of paper presented 14th Conference Great Lakes Research, Toronto. April 19-21, pp. 95-96.

The present study of variability of runoff in the Lake Ontario basin provides background information for the International Field Year on the Great Lakes in 1972, since it is realized that a period of 1 year is a small sample in the life history of a lake basin and there are large annual fluctuations in the variables in the water balance. In their study of the hydrology of Lake Ontario, Morton and Rosenberg concluded that most of the annual variation in water level is caused by variation in the net basin supply. The largest variable increasing the basin supply is the runoff averaging 46 to 56 inches compared to evaporation of 24 to 36 inches, and precipitation of 28 to 32 inches.

Sato, G. K. - See: G. K. Rodgers, No. 331.

342. Schutze, L. T. 1966. Determination of flow over Niagara Falls. U. S. Lake Survey, Army Corps of Engineers. Bulletin B66-1, pp. 1-9.

By a treaty signed in 1950 the flow of water over Niagara Falls cannot be reduced beyond certain values by the Niagara Falls Power plants. The variations in flow caused by the power intakes have a significant effect on currents, water depth and velocity flow of water in the lower Niagara River. Mathematical Models and formulas are used in flow and diversion variation analysis. (Canada Centre for Inland Waters).

Scott, J. T. - See: U. H. Czapski, No. 144.

Scott, J. T. - See: D. R. Landsberg, No. 243.

343. Scott, J. T., P. Jekel and M. Fenlon. 1971. Transport in the coastal current near the south shore of Lake Ontario in early summer. Abstract of paper presented at 14th Conference Great Lakes Research, Toronto, 19-21 April. p 45.

In early summer, the currents along the south shore of Lake Ontario, are primarily baroclinic and concentrate in a fairly narrow band or "coastal jet." These boundry modified coastal currents are generally set up by the relatively strong winds following the passage of summer cyclones and cold fronts. The paper describes a study of the transport and pattern of a coastal current which resulted from a typical summer storm on July, 1970.

Current velocity and temperatures were measured to 40 m depth. Dynamic height patterns, cross sections of temperature and computed baroclinic geostrophic velocity all showed spacial and temporal consistency for the six day period.

The coastal current was the major consistent feature of the circulation pattern. The six day means of the measured and computed transport were nearly the same indicating that the steady coastal current in Lake Ontario is primarily baroclinic in early summer.

344. Scott, J. T. and D. R. Landsberg. 1969. July currents near the south shore of Lake Ontario. Proceedings 12th Conference Great Lakes Research. pp. 705-722.

Drogue Measurements of current direction and speed at five anchored buoys near the south shore of Lake Ontario from 11-20 July 1968 near Fairhaven, N. Y., showed that total transport in the 35 m layer was north-eastward along the shore. However, at stations 1 and 2 km from the shore there was a southwestward flowing "countercurrent." The maximum northeastward coastal jet was normally located from 6-10 km from shore. Baroclinic geostrophic transport was computed from daily temperature soundings at 10 stations. Internal waves and wind fluctuations did not mask the baroclinic geostrophic flow for this near shore case. Baroclinic geostrophic flow and total transport were to the northeast in the surface layers, but the analysis indicated that there was a slow return flow opposed to these.

Transport in deep water was, therefore, southwestward. The baroclinic geostrophic computation was a good predictor of surface currents in summer when the latter are much larger than the steady return barotrophic flow.

345. Scott, J. T. and L. Lansing. 1967. Gradient circulation in eastern Lake Ontario. Proceedings 10th Conference Great Lakes Research. pp. 322-336.

Thermal patterns in eastern Lake Ontario are examined to determine themagnitude and cause of baroclinicity which produces gradient (nearly geostropic) currents. A strong gradient current flows eastward along the south shore and northward along the east shore in early summer. This current is probably caused by a combination of local heating due to differences in lake depth and coastward advection of warm surface water by Eckman transport. Evidence of persistent baroclinicity in late summer was not found but may have been masked by verticle displacement of the strong thermocline.

346. Scovell, J. T. 1890. An old channel of the Niagara River. American Association Advancement of Science. 39th Meeting, pp. 245-246.

It is believed that the waters of Lake Erie formally flowed into Lake ontario by a channel some miles west of their present course, and that the retreating glacier so obstructed this old channel that the waters were compelled to take a new course forming the Niagara River. Geologists believe the time between the present and the glacial retreat is approximately 10,000 years.

347. Simons, T. J. 1971. Development of numerical models of Lake Ontario. Unpublished paper presented at 14th Conference Great Lakes Research, Toronto, April 19-21, 1971. p.6-7.

At the Canada Centre for Inland Waters, a program has been initiated to simulate the water motion in Lake Ontario by numerical models. The program consist of evaluating existing numerical techniques, developing an hierarchy of models describing the circulation of the lake under various conditions and an extensive verification program for the purpose of evaluating the degree of accuracy of the various models by comparison with the abundance of observational data to become available during the year 1972.

Simpson, R. B. - See: D. V. Anderson, No. 15.

348. Simpson, R. B. and D. V. Anderson. 1964. The periods of the longitudnal surface seiche of Lake Ontario. Great Lakes Research Division, Univ. of Michigan, Ann Arbor. Publication 11, pp. 369-381.

Proudman's method allows calculation of the period of a seiche from the actual configuration of a lakes basin. This method has been adapted to automatic computation and used to determine the uninodal and binodal periods of the longitudnal surface seiche of Lake Ontario. These are 5.41 and 2.48 hours, respectively.

349. Simpson, R. B. and D. V. Anderson. 1967. The surface tides of Lake Ontario. Ontario Department of Lands and Forests. Research Report No. 76. 42 p.

This report describes work started by Dr. Anderson when he was with the Department of Lands and Forests.

Monthly averages of surface levels, at successive hours, reveal the lunar and solar tides of Lake Ontario. The relative amplitudes and phases in the eastern, central and western basins are in accord with theory. It is suggested that intensive tidal studies will help unravel puzzles in circulation and that they may be useful in constructing correlations with seasonal meteorological changes.

350. Simpson, W. G. and G. K. Kamitakahara. 1971. Opinions on recreation and pollution in Lake Ontario. Univ. of Toronto, Great Lakes Institute. 10 p.

Data collection techniques are used to ascertain pollution levels in various parts of the lake.

351 Simpson, W. G. and G. K. Rodgers. 1970. Currents in Lake Ontario near Toronto. Proceedings 13th Conference Great Lakes Research. pp. 528-539.

Current measurements have been made for 4 years at one location in 10 m of water near Toronto. A summary of these data, in time series and frequency distributions, and a relation between current and wind, found by an empherical analysis are given. This relation permits prediction of currents at this location.

352. Sissons, J. B. 1966. Subglacial, marginal and other glacial drainage in the Syracuse-Oneida area, New York. Bulletin of the Geological Society of America. 71: 1575-1588.

In his numerous papers on central New York, H. L. Fairchild interpreted almost all the glacial-drainage features as of marginal origin. In the Syracuse-Oneida area, however, there is morphological evidence of subglacial stream erosion by both local and Great Lakes waters, of subglacial deposition by local waters, and of englacial flow in places. Evidence also indicates that the Great Lakes waters in some places flowed in channels walled by ice. Only limited evidence of ice-dammed lakes exists in the Syracuse-Oneida area itself, except at the lowest altitudes, where numerous small shore features indicate a former local lake above the highest Iroquois shore line. There is evidence of two periods of Great Lakes drainage across the hillslopes of the Syracuse-Oneida area during the oscillatory retreat from the Wisconsin maximum. The writer suggests, however, that these two periods of Great Lakes drainage alone are insufficient to account for the vast, complex channel system.

353. Slater, G. 1969. The structure of the drumlins exposed on the south shore of Lake Ontario. NYS Museum Belletin No. 281. 16 p.

The drumlins on and adjacent to the southern shore of Lake Ontario are unusual size and development.

The sections are usually transverse and lie across the exposed or "iceward" ends of the drumlins.

Two phases of structure are shown, marked by a gradual change in the lithology. A lower "core" of stiff boulder clay passes gradually into bedded material above, consisting of stoneless clays, loams and boulder clay, associated in some cases with "wisps" and lenticles or streaky sand.

The "core" has acted as an obstruction to the passage of later material, resulting in the accretion of new material, which has moved along "glide" or thrust planes, thus producing suitable gradients. Pressure has occurred both longitudinally and laterally, the former being predonimant.

354. Sly, P. G. 1969. Sedimentological studies in the Niagara frea of Lake Ontario and in the area immediately north of the Bruce Peninsula and Georgian Bay. Proceedings 12th Conference Great Lakes Research. pp. 341-346.

A study of the bottom sample variance in different environments in the Great Lakes was begun in 1967. By the end of 1969, two areas will have been completely surveyed; one around the Niagara River Mouth on Lake Ontario, and the other around Georgian Bay, near the tip of the Bruce Peninsula. A preliminary study of the third area in Lake Ontario near Kingston, is to begin in 1969. A special sampling grid, covering an area of about 150 km^2 has been devised for use in all the study areas and sampling has been designated to yield material for sedimentological studies, geochemical and biological studies. Underwater photography has been used to provide visual records of the lake bottom. Echo sounding, side scan sonar, and continuous seismic profiling has been used to obtain sub-bottom penetration and complete physiographic coverage.

355. Smith, H. M. 1892. Report of an investigation of the fisheries of Lake Ontario. Bulletin U. S. Fisheries Commission. 10: article 6. pp. 177-215.

A section included in this article covers such physical characteristics of Lake Ontario as: temperature, depth, sediment, currents and winds. They are discussed as to their relationship with the fish in the area.

356. Spencer, J. W. 1882a. A short study of the features of the region of the lower Great Lakes during the great river age: or notes on the origin of the Great Lakes of North America. Proceedings American Association Advancement of Science, 30th Meeting. pp. 131-146.

The author follows the origin of several great rivers and their altering patterns before, during and after the glacial ages. The Great Lakes were formed by a complex system of evolution involving river and glacial processes.

357. Spencer, J. W. 1882b. Terrances and beaches about Lake Ontario. American Journal of Science. 24 (3d Series): 409-416.

The author concentrates on the Western end of Lake Ontario to analyze the location, characteristics, properties and structures and occurrences of lake beaches above the present water level of Lake Ontario. The author recommends an extensive analysis to determine ancient lake level variation and possible centimental movements along with the accompanying geological evolution of the region.

358. Spencer, J. W. 1889a. The Iroquois Beach. A chapter in the geological history of Lake Ontario. Transactions Royal Society of Canada, Section IC. pp. 121-134.

Variation in beach height indicates great warping of the earths crust in recent times. Charts of location and elevation variation are presented. The geological history of beach formations and the accompanying lake levels reveals much of the glacial and past glacial history of Lake Ontario. Much of the beach material are products of erosion. The estimated age of the beach is 14,000 to 15,000 years.

359. Spencer, J. W. 1889b. Notes on the origin and history of the Great Lakes of North America. Proceedings American Association Advancement of Science, 37th Meeting. pp. 197-199.

The discussion of the evolution of the Great Lakes basin includes: discovery of the ancient course of the St. Lawrence River, Origin of the Great Lakes basins, establishment and dismemberment of Lake Warren, discovery of the outlet of Huron-Michigan-Superior Lake into Lake Ontario, by the Trent Valley and Erie, the youngest of all the Great Lakes.

360. Spencer, J. W. 1890. Ancient shores, boulder pavements and highlevel gravel deposits in the region of the Great Lakes. Bulletin of the Geological Society of America. 1: 71-86.

The discussion in this article includes: ancient Great Lakes shoreline characteristics, comparison of ancient and and modern shoreline characteristics, boulder pavements and ancient beaches, accumulation of ancient boulders, distribution of surface boulders, high level gravel deposits in the Great Lakes region, drift buried gravel deposits and surface gravels and sands.

361. Spencer, J. W. 1891. High level shores in the region of the Great Lakes and their deformations. The American Journal of Science. 3d Series. 41: 201-211.

An investigation of high beaches, fossils, sediments and topography has led the author to believe the levels of the Great Lakes were once much higher than the present lakes are. The author lists the various lakes, the high beaches and evidence and then estimates the highest levels attained by these lakes.

362. Spencer, J. W. 1894. Deformation of the Lundy Beach and Birth of Lake Erie. American Journal of Science. 3d Series. 47(270): 207-212.

Article on the formation of Lake Erie followed chronologically through various geologic ages. Secondary information is presented on some aspects of Lake Ontario formation and geology.

363. Spencer, J. W. 1895 a. The duration of Niagara Falls and the history of the Great Lakes. Humboldt Publishing Company, New York. 126 p.

The geology (preglacial, glacial and post glacial aspects) of the Great Lakes basin region with emphasis on properties and structures, formation, age and erosion. (Royal Ontario Museum).

364. Spencer, J. W. 1895b. The geological survey of the Great Lakes. Proceedings American Association Advancement of Science, 43rd Meeting. pp. 237-248.

Discussion of the Great Lakes basin includes: problems and progress, former high continental elevation, lake basin characteristics, glaciation, the buried Lawrentian Valley, buried tributaries, reversal of the ancient drainage of the Ohio and other rivers, closing of the valleys into the lake basin, deserted beaches in the lake region and their deformation, Warren water and the birth of the lakes, Algonquin and Fundy waters, Iroquois water--birth of the modern lakes, drainage of the Great Lakes into the Mississippi by way of Chicago and the history of the Niagara River and changes of the outlets of the lakes.

365. Spencer, J. W. 1898a. Another episode in the history of Niagara Falls. American Journal of Science, 4th Series. 6: 439-450.

Discussion in this article includes: the changing physics of the river, a revision of the episodes of Niagara River, the newly discovered episode, the Niagara Strand, the modern episode, the rise of the Ontario waters, and explanation of the narrows of the gorge at the Whirlpool Rapids.

366. Spencer, J. W. 1898b. Another episode in the history of the Niagara River. Abstract of paper presented at American Association Advancement of Science, 47th Meeting. p. 299.

This paper is a sequel to the one read before the American Association four years ago on the duration of Niagara Falls. It announces the discovery that while the falls were receding from Foster's flats to the locality of the railway bridges, the fall of the river reached its maximum amount of 420 feet by the retreat of the Ontario waters toward the north; and that, during the later part of this recession of the falls, past the Whirlpool rapids, the return to the present amount of 326 feet descent was interrupted by the rising of the level of the lake in the gorge to a height of 75 feet above its present level, thus reducing the actual fall of the river to 250 feet. The evidence of this is preserved in the remains of a terrace deposit opposite the foot of Foster's flats and a corresponding terrace just outside the mouth of the gorge; and these terraces, with other parts of the shore line in the Ontario basin which marks the rise of the waters so as to flood the Niagara Gorge, are here named the Niagara strand.

The rising of the waters was occasioned by the lifting of the barrier at the outlet of Lake Ontario to an elevation 100 feet higher than now. By the subsequent erosion of this barrier, which was partly composed of drift, the actual fall of the Niagara waters has been increased to its present figure.

The reduction in the descent of the river is found to be sufficient to account for the shallowness of the channel at the Whirlpool rapids. The narrowness of this section is explained by the fact that the youghful Niagara took possession of a small preglacial valley there, giving greater depth to the river. It is further probable that the volume of the river was less at that time, since it is supposed that a portion of the outflow of the Great Lakes passed to the Mississippi.

367. Spencer, J. W. 1907. The falls of Niagara. Canadian Department of Mines, Geological Survey Branch, Ottawa. 490 p.

A discussion of the evolution or formation of the falls and the varying relationship to the Great Lakes. Also included is a discussion of power uses and diversions with the accompanying effect on the flow volume and asthetic value of the falls. (Schoellkopf Museum, Niagara Falls, New York).

368. Spencer, J. W. 1917. Origin and age of the Ontario shoreline. American Journal of Science. Series 4. 43: 359.

The modern beach of Lake Ontario is the last of the shore lines about the lake basin to be studied with sufficient precision for writing its history. Much attention has been given to the higher water planes, especially to the Iroquois beach, not only shifting the lake at a high level but tilted by subsequent earth movements, so that is now rises 540 ft. between the heaf of the lake and the Galops Rapids of the St. Lawrence River (66 miles below the lake outlet), which form the first rocky barrier to the lake basin. In sinking from the higher beach, the waters fell to more than 200 ft. below the present level (at Niagara River), before the warping of the earth's crust raised the barrier to the lake basin, so the waters rose to a few feet above the present Ontario shoreline, from which they have since been lowered, owing to the scour of the St. Lawrence River after the river sunk within its channel.

The age of the Ontario Beach is about 2,000 years, while the age of the lake itself and the St. Lawrence River is 3,500 years, or perhaps slightly less.

Sporns, U. - See: D. V. Anderson, No. 11.

Stewart, R. - See: U. H. Czapski, No. 144.

369. Stewart, R. 1969. Thermal discharge from nuclear plants and related weather modification. Proceedings 12th Conference Great Lakes Research. pp. 488-491.

The volume of thermal discharge from power plants is increasing at a rate which suggests that the discharge will cause inadvertent weather modification. A 10^3 M.W. nuclear power plant uses approximately 10^6 gal/min. of which 10^4 gal/min. evaporates. This is sufficient to reduce visibility and incraase fogging in the area of discharge. Beneficial uses of thermal discharge are suggested and calculations are presented to indicate that waste heat released by a dry closed-circuit-cooling system is sufficient to dissipate fog and increase visibility. An example is used in the Lake Ontario shoreline near Rochester.

370. Storr, J. F. 1963. Surface currents on Lake Ontario between Oswego and the eastern end of the lake for period of June, July and August 1963. Great Lakes Research Division, Univ. of Michigan. Publication 11. p. 390.

The effluent of Oswego River was used to trace the curren (chloride analysis - 100-200 times that of lake water). The continuity of this data, as well as the availability of a continuous record of wind direction and force makes it possible to trace each change in the current pattern and to relate these changes directly to wind direction and to relate these changes directly to wind direction and velocity. A chronological account of the current pattern is presented with emphasis in the 3 basic patterns of the current complex and various phenomena that were encountered

371. Straw. A. 1968. Late pleistocene galcial erosion along the Niagara escarpment of southern Ontario. Bulletin of Geological Society of America. 79: 889-910.

A large number of re-entrants in the Niagara Escarpment, severly indenting the outcrop of the Lockport-Amabel dolomite, are defined and their morphologic characteristics are believed to have been induced largely by glacial agencies, and various ice movements over the Niagara scarp during the Wisconsin Glaciation are determined from a consideration or moraine and drumlin trends and meltwater drainage lines. Three main phases of ice advance and recession within the Late Wisconsin and a general advance within the Early Wisconsin are envisaged, during which ice repeatedly flowed along and probably greatly enlarged many of the re-entrant valleys.

Large-scale glacial erosion is demonstrated along the Niagara scarp where it fronts onto Georgian Bay, and comparison is made between this area and the Finger Lakes region in New York state. Less intense erosion is considered to have affected the remainder of the scarp, though the Dundas valley is also regarded as a major glacial trough. These conclusions weigh heavily against contentions that recognizable "preglacial" features persist along or in front of the Niagara Escarpment, and a brief re-evaluation of previously postulated "preglacial" drainage system is made.

372. Stupart, R. F. 1913. IV. The climate of Toronto. In: Faull, J. H. (ed.). The Natural History of the Toronto region. Canadian Institute, Toronto. p. 82-90.

Toronto's climate is affected by Lake Ontario due to its position on the shore of the lake. Meterological elements discussed are temperature, precipitation, winds and barometric pressure. (Royal Ontario Museum, Toronto).

Sutton, R. G. - See: D. L. Woodrow, No. 436.

373. Sutton, R. G., T. L. Lewis and D. L. Woodrow. 1970. Near shore sediments in southern Lake Ontario, their dispersal patterns and economic potential. Proceedings 13th Conference Great Lakes Research. pp. 309-318.

The southern Lake Ontario near-shore consists of boulders and till (75%), and bedrock (10%), and sand and gravels (15%). Potential economic sand deposits in excess of 100 million cubic yards occur at Niagara, Rochester and along the eastern shore. Smaller deposits occur at Hamlin Beach and Mexico Bay. Elsewhere, the sand forms small isolated patches.

The beach sands are generally restricted to areas adjacent to stream mouths or spits and bars extending across the fronts of bays and ponds where effects of the prevailing easterly currents are locally reduced. The sand fine lakeward and are displaced by muds in depths of over 50 ft. 15 m) and at offshore distances greater than two miles (3.2 km). The sands generally fine from west to east.

The average sand is composed of quartz, feldspar, rock fragments and heavy minerals (7%). Most of the sand originated from erosion of submerged tills, till cliffs and streams.

374. Sutton, R. G. and N. A. Rukavina. 1965. Changes in the level of Lake Ontario as inferred from offshore sediments at Broddock Heights, New York. Proceedings of Rochester Academy of Science. 11(2): 72-82.

The Department of Geology at the University of Rochester undertook an exploratory survey of the Lake Ontario near-shore bottom near Braddock Heights, New York. The lake currents in the area were generally moving west to east with a decrease in strength corresponding with greater depth. Particle size in the lake sediments should decrease as depth increased. If the lake rises, finer material will settle over coarser material. The survey discovered an area approximately twenty-five feet deep where a higher percentage of course material was discovered leading to the conclusion that the lake has risen 24-30 feet from the initial beach area.

375. Sutton, R. G., N. A. Rukavina and E. L. Towle. 1965. Lake Ontario shoreline processes and evolution at Braddock Heights, New York. Report of progress. Great Lakes Research Division, Univ. of Michigan, Publication 13, pp. 240-247.

Two types of sand can be identified in the offshore of Lake Ontario near Braddock Heights, New York. One occurs in deeper waters and is rather poorly sorted, coarser grained and contains a high percentage of fines. The second type is well sorted, finer grained and occurs in shallow water. The first type is deposited in deep water at times of storm activity; the second is a product of wave action and longshore currents from the northwest.

Cores reveal an organic rich layer that represents older bay deposits when the lake level rose. Drumlins that flanked the older bay were eroded away and their sites are marked by boulders.

The planned construction of an artificial shoal in the study area will afford a unique opportunity to study the changes in sediment distribution resulting from the modified current and wave patterns.

376. Sweers, H. E. 1968. Structure of the thermocline during the summer in Lake Ontario. 11th Conference Great Lakes Research, Milwaukee, Wisconsin. p. 45.

The Great Lakes Division, Department of Energy, Mines and Resources, collected, among other data, a large number of temperature observations on Lake Ontario during the 1966-67 field seasons. These data have been analysed with special attention to the horizontal distribution of the depth of the thermocline and the verticle temperature structure. Persistent and transient patterns in the lakewide distribution of the depth of the thermocline are pointed out and an effort has been made to interpret changes in this pattern in terms of transport phenomena and to relate them to the windfield. The intensity of the maximum verticle temperature gradient is discussed and related to wind strength, depth of the thermocline and depth of the lake at the sampling station.

377. Sweers, H. E. 1969. Structure dynamics and chemistry of Lake Ontario. Department of Energy, Mines and Resources, Ottawa. Manuscript Report Series No. 10. 227 p.

Data obtained from a series of monitor cruises on Lake Ontario during the 1966-67 field seasons are analyzed. A study of the thermal regime is analyzed utilizing the rare natural versus random variability analysis of the data. Thermal stratification development, characteristics and dissipation are discussed with special reference to upwellings, regional temperature anomalies in relation to wind and river flows, mixing and any deviations from the normal.

A flushing model is perfected along with the development of an equation to calculate eddy diffusivity. Seasonal heat content changes are calculated. The lake during the summer months is concluded to be well mixed horizontally.

378. Sykes, R. B. 1964. Lake weather phenomena (LWP) Oswego, N. Y. Area Progress Report. Great Lakes Research Division, Univ. of Michigan. Publication 11, p. 321.

Progress report summarizes the Oswego area approach to study of the snow features of the Lake Weather phenomena. 1963-64 observations from the southeast side of Lake Ontario revealed some interesting examples of widespread convection over the lake accompanied by some curious mammatiform clouds at low levels. Checks with people living near the lake for several years suggest some uncommon aspects about certain forms and distributions of clouds this season.

379. Taylor, B. 1895. Niagara and the Great Lakes. The American Journal of Science. 49(Series 3): 249-270.

A lengthy discussion of the formation of the Great Lakes basins and their respective evolution. The existence of preglacial rivers is thought to be the factor resulting in the original basin formation. Alterations due to glacial advances retreats and deposits established and altered the entire flow system until the general topography of modern times was established. Much information is presented on the origin, evolution and effect on Great Lakes levels, of the development and changes in the Niagara River.

Taylor, F. B. - See: F. Leverett, No. 249.

Taylor, F. B. - See: E. M. Kindle, No. 237.

380. Taylor, F. B. 1898. Origin of the gorge of the whirlpool rapids at Niagara. Bulletin of the Geological Society of America. 9: 59-84.

For as much of the Niagara gorge as is brought under discussion in this paper, the correlations between the gorge and the lakes seem clear and complete, point for point and episode for episode. They may be summarized briefly as follows:

1. The episode of the Middle Great gorge, extending from Wintergreen falt up to the upper side of the Eddy basin, is the correlative of the latter part of the episode of lake Algonquin--that part which comes after the closing of its Trent Valley outlet, supposing the lake to have drained for a time in that direction.

2. The place of the sudden contraction of the gorge at the upper side of the Eddy basin is the correlative of the breaking of the ice-dam in the Ottawa valley and the opening of northeastward drainage--the end of Lake Algonquin.

3. The episode of the gorge of the Whirlpool rapids is the correlative of the episode of Nipssing Great Lake with the Nipissing-Mattawa River at its outlet--episode of the Champlain marine submergence.

4. The place of expansion at the lower end of the Upper Great Gorge above the railroad bridges is the correlative of the change of outlet of the upper lakes from North Bay to Port Huron--the beginning of the Champlain uplift.

5. The episode of the Upper Great Gorge is the correlative of the modern of post-champlain episode of the upper Great Lakes.

381. Taylor, Frank B. 1926. Evidence of recurrent depression and resilience in the region of the Great Lakes. Papers of the Michigan Academy of Science, Arts and Letters. 7: 135-143.

On theoretical grounds depression and resilience of the land in the Great Lakes region have occurred in connection with at least the last three of the Pleistocene ice sheets. Evidence used is that of the successive Niagara gorges - the gorge of the Wisconsin Niagara (now in the making); the gorge of the Illinoian Niagara (the buried St. David's gorge, and the gorge of the Kansan Niagara)

(Spencer's Erigan Canyon). Included is a sketch map of part of the Niagara Peninsula between Lakes Erie and Ontario showing the location of the Niagara escarpment and the three gorges described in the text.

382. Taylor, P. A. 1969. Numerical models of airflow above Lake Ontario. September 1, 1968 and May 31, 1969. (Final Report on IFYGL sponsored research. Research sponsored by Meteorological Branch). Univ. of Toronto, Department of Mathematics. 65 p.

A numerical model of airflow in the lowest 50-100 m of the atmosphere above changes in surface roughness and temperature or heat flux has been developed based on boundary layer approximations, the Businger-Dyer hypotheses for the non-dimensional wind shear and heat flux and a mixing-length hypothesis.

Results have been obtained from several situations, in particular, airflow with neutral upstream conditions encountering a step change in surface temperature or heat flux with no roughness change. In these cases large increases in shear stress at the outer edge of the internal boundary layer are predicted. The case of unstable upstream flow encountering a step change to zero heat flux is also considered.

Finally, two situations thay may be encountered near the shores of the Great Lakes are considered. Results are presented using typical values of roughness, temperature, etc. for cases of cold air advection off the land onto a lake in winter and the lake breeze in summer. Recommendations are made regarding the IFYGL observational programme. (Canada Centre for Inland Waters).

Terasmae, J. - See: G. D. Hobson, No. 207, 208.

Terasmae, J. - See: P. F. Karrow, No. 228.

383. Thomas, J. F. J. 1954. Industrial water resources of Canada water survey report No. 3, Upper St. Lawrence River-Central Great Lakes Drainage Basin in Canada. Canada Department Mines and Technical Surveys, Mines Branch, Ottawa. 212 p.

Tabulated data for the surface water of Lake Ontario are presented on: water temperature, water levels, specific conductance, turbidity, suspended matter, color and discharge. Descriptive statements are included which give date and location of sampling and depth of sampling. (Canada Centre for Inland Waters).

384. Thomas, M. K. 1953. Climatological atlas of Canada. National Research Council, Ottawa. No. 3151, 255 p.

Included in this comprehensive climatological report are the following parameters pertaining to the Lake Ontario region.

1. Temperature - seasonal variations.
2. Humidity.
3. Wind - mean velocity and direction.
4. Snow.
5. Precipitation.
6. Radiation and cloud cover.
7. Seismological disturbance.

(Univ. of Toronto, Zoological Library)

385. Thomas, M. K. 1964. A survey of Great Lakes snowfall. Proceedings 7th Conference, Great Lakes Research Division, Univ. of Michigan. Publication 11. pp. 294-310.

Survey results of snow measurement on Lake Ontario date back to 1842. Snowfall in the Great Lakes basin is produced by both large scale cyclonic storms and by the relatively small lake effect storms. Lake effect storms seem to have greater yearly and decade to decade fluctuations.

386. Thomas, M. K. and S. R. Anderson. 1967. Guide to the climatic maps of Canada. Department of Transport, Meteorological Branch, Toronto. 107 p.

This article provides an explanation of parameters mapped, a subject and publication guide, and an index of important maps published. It is designed to reduce the effort in locating and abstracting various climatic maps of Canada. Accompanied with the article are several climatic maps on temperature, precipitation and barometric pressure along with their seasonal variations. (Univ. of Toronto, Zoology Library).

Thomas, R. L. - See: P. S. Cronan, No. 134.

387. Thomas, R. L. 1969a. A note on the relationship of grain size, clay content, quartz and organic carbon in some Lake Erie and Lake Ontario sediments. Journal of Sedimentary Petrology. 39(2): 803-809.

An examination of the geochemistry of fine grade sediments in relation to size frequency distribution was carried out on sediment samples from Lakes Erie and Ontario. This study demonstrated a direct relationship between the 2 micron grain size and the theoretical clay content computed from the organic carbon, quartz and carbonate content. A sympathetic relationship was observed between clay content and organic carbon, and also between grain size and quartz content. The former relationship is believed to be the result of absorption from solution and the latter is brought about by natural sedimentation from suspension.

388. Thomas, R. L. 1969b. The qualitative distribution of feldspars in surficial bottom sediments from Lake Ontario. Proceedings 12th Conference Great Lakes Research. pp. 364-379.

A qualitative assessment of the feldspar distribution in Lake Ontario sediments has been made by the determination of the feldspar end members, K, Na and Ca, on sediment residues after fusion with potassium pyrosulphate. Both K absorption and cation exchange of Na and Ca for K in standard feldspars was observed. Cation exchange is shown to be minimal in samples and in standards with a full particle size range. K absorption is high yet appears to be constant and not directly related to grain size. In the inshore zones a poor positive correlation of feldspar to quartz is believed to be the result of poor mixing in the traction load sediment. In the basin zones, the relationship is of a higher order and reflects natural sorting by sedimentation from a suspended load.

The regional distribution of the feldspars shows an inshore to offshore decrease, initially, of calcic feldspar, then of sodic feldspar leading to a basin enrichment of the potash feldspars, microcline and orthoclase. The feldspars are probably derived predominantly by coast line erosion of galcial deposits surrounding Lake Ontario.

389. Thomas, R. L., A. L. W. Kemp and C. F. M. Lewis. 1970. The distribution and characteristics of Lake Ontario surface sediments. Abstract of paper presented at Annual Meeting Geological Society of America. p. 703.

By use of grab samples and bottom echo sounding, the following parameters were measured: Sediment particle size, pH, E.H., organic carbon, carbonate carbon, quartz content and mineral clay.

Three basin areas were recorded:
1. Nearshore - glacial meterial.
2. Offshore - covered clays deposited in Lake Iroquois.
3. "Further Offshore" - silty clays.

The modern sediments of the lake prograde offshore into deeper waters of each depositional basin. From inshore to offshore, a decrease in mean grain size is associated with a decrease in quartz and an increase in organic carbon and clay content. Carbonate compounds are derived from weathering limestone in the bottom areas.

390. Thompson, J. H. 1966. The geography of New York.
Syracuse University Press, Syracuse, N. Y. 53 p.

The geography of New York State is discussed in relation to lakes, rivers, topography, geographical features, mountain formations, glacial developments and deposits.

391. Touvell, W. M. 1965. The Niagara River escarpment.
Royal Ontario Museum, Univ. of Toronto. 16 p.

The "What, why, when, how, where and who" of the existence and formation of the Niagara Escarpment. Along with a discussion of the geology of the area, the author inlcudes the process of formation of the Niagara Escarpment along with the subsequent formation and erosion of Niagara Falls. (Canada Centre for Inland Waters).

392. Touvell, W. M. 1966. Niagara Falls, story of a river.
Royal Ontario Museum, Univ. of Toronto. 16 p.

The "What, why, when, how, where and who" answers about the formation and existence of Niagara Falls. The author follows the process of Geological formation and erosion along with an indepth discussion of the geology of the area in reference to velocity of erosion. (Canada Centre for Inland Waters).

Towle, E. L. - See: R. G. Sutton, No. 375.

Traversy, W. - See: V. K. Chawla, No. 100.

393. U. S. Congressional House Committee on Foreign Affairs.
1914. Diversion of water from the Great Lakes and Niagara River. 63d Congress, 2d Session. Vol. 1.

A discussion of the use of additional water from the Niagara River for power utilization. Involves legal aspects, effects on water levels in the river and associated lakes and river shore ownership and utilization policies. Several papers are included in one volume which represents the stated opinions of various experts and dignitaries.

394. U. S. Department of Interior. 1963. Water levels of the Great Lakes. Fish and Wildlife Serivce. 60 p.

The current Corps' plan to regulate the levels of the Great Lakes (Plan 57-EO-1 of Plan C) will affect only Lake Erie. A test of this regulation plan over a 91-year period of record revealed that the maximum mean level at Lake Erie (573.71) would have been 1.03 feet below the recorded adjusted level, and that the minimum mean level (570.51) would have been 0.68 feet above the recorded adjusted level, an average range of stage of 3.20 feet. In other words, the plan will moderate the fluctuations of the lake by reducing the high levels and by raising the low levels. The highs usually occur between May and July, and the lows are in December and January.

No evidence has been found which would indicate that this plan will have any marked effect on the fishery resources of Lake Erie.

The principal wildlife resources of Lake Erie are in the form of extensive marshes which provide valuable waterfowl and fur-animal habitat. Due to the gradual gradient at the weatern end of the lake, water level fluctuations can affect large acreages of these marshes. Fluctuations are cuased by seiches, as well as by seasonal changes in the lake level.

Most of these marshes are developed as wildlife habitat by either public agencies or private hunting clubs. Development is primarily in the form of dikes, water control structures and pumps which permit control of water levels in the marshes independent of lake levels. However, high lake levels coupled with strong winds can be damaging to these developments and maintenance costs are high. The Corps' regulation plan will help to reduce these high levels and thus alleviate the maintenance problem.

Although high lake levels may be undesirable inso far as controlled marsh areas are concerned, they may be beneficial in their effects on uncontrolled marsh areas. High levels enhance the quality of these marshes by creating openings in solid stands of emergent marsh vegetation. However, most marsh areas are now under control so this beneficial aspect of high levels is limited to the few remaining uncontrolled areas.

In conclusion, it may be stated that the overall effects of the Corps' regulation Plan 57-EO-1 will be beneficial to wildlife resources of the Lake Erie area. So far as it can be determined at this time, the plan will not change the fishery resources of Lake Erie. (Canada Centre for Inland Waters).

395. U. S. Department of Interior. 1965. Water resources data for New York, surface water records. Geological Survey. Parts 1 and 2. 378 p. and 112 p, respectively.

This paper contains extensive depth and discharge data for Lake Ontario tributaries. Information is presented on data collection, processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation. Information is given in part two about ground water, precipitation, water temperature and sedimentation.

396. U. S. Department of Interior. 1966a. Statement on water pollution in the Lake Ontario basin. Federal Water Pollution Control Administration, Great Lakes Region, Chicago, Illinois. 48 p.

The sources, amounts and effects of pollutants in the Lake Ontario Basin. Each major tributary, inflow and outflow is isolated and analyzed for flow volume, runoff, pollutants, demographic data, temperature, geology, water uses and recreation. All data is then tied together to give an all-over picture of the situation in the Lake Ontario basin.

397. U. S. Department of Interior. 1966b. Water resources data for New York, surface water records. Geological Survey. Parts 1 and 2, 363 p and 167 p, respectively.

This paper contains extensive depth and discharge data for Lake Ontario tributaries. Information is presented on data collection, processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation. Information is presented in part two about ground water, precipitation, water temperature and sedimentation.

398. U. S. Department of Interior. 1967a. Water oriented outdoor recreation in the Lake Ontario basin. Bureau of Outdoor Recreation, Ann Arbor, Michigan. 108 p.

This article contains extensive data on physical and dimensional parameters of Lake Ontario. The location, climate, land features, water characteristics (lake levels, currents, seiches), land and water uses, water supply and pollution are all discussed in this article. (Canada Centre for Inland Waters).

399. U. S. Department of Interior. 1967b. Water Resources data for New York, surface water records. Geological Survey. Parts 1 and 2, 375 p. and 159 p., respectively.

This paper contains extensive depth and discharge data for Lake Ontario tributaries. Information is presented on data collection, processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation. Information is given in part two about ground water, precipitation, water temperature and sedimentation.

This paper contains extensive depth and discharge data for Lake Ontario tributaries. Information is presented on data collection, processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation. Information is given in part two about ground water, precipitation, water temperature and sedimentation.

400. U. S. Department of Interior. 1968. Water Resources data for New York, surface water records. Geological Survey, Parts 1 and 2. 300 p. and 137 p., respectively.

This paper contains extensive depth and discharge data for Lake Ontario tributaries. Information is presented on data collection, processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation. Information is given in part two about ground water, precipitation, water temperature and sedimentation.

401. U. S. Department of Interior. 1969. Water Resources data for New York, surface water records. Geological Survey, Parts 1 and 2. 283 p. and 119 p., respectively.

This paper contains extensive data on discharge and tributary depth of rivers flowing into Lake Ontario. Information is presented on data collection, processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation. Information is given in part two about ground water, precipitation, water temperature and sedimentation.

402. U. S. Department of Interior. 1970. Water Resources data for New York, surface water records. Geological Survey. 301 p.

This paper contains extensive data on discharge and depth of tributary flow into Lake Ontario. Information is presented on data collection and processing methods and equipment (gauging stations). The stations reveal seasonal, monthly and daily discharge variation.

403. U. S. Fish and Wildlife Service. 1969. Fish and Wildlife as related to water quality of the Lake Ontario basin. Fish and Wildlife Service, Washington, D. C. 128 p.

Included in this report is a discussion of the morphometry, thermal conditions, light penetration, transparency and currents of the Lake Ontario basin. Pollution in the various subbasins (Niagara River, Genesee River, Oswego River, Black River and St. Lawrence River) is also discussed.

404. U. S. Geological Survey. 1948. Ground water supply of the United States - 1948. Geological Survey Water Supply Paper 1114. U. S. Government Printing Office, Washington, D. C. Part 4. 296 p.

Extensive data is presented on ground water levels throughout the United States. The report is broken into small areas (cities, counties, etc.) and into yearly analysis to give accurate analyses of level fluctuations. Very little discussion accompanies the data.

405. U. S. Geological Survey. 1952. Ground water supply of the United States - 1950. Geological Survey Water Supply Paper 1174. U. S. Government Printing Office, Washington, D. C. Part 4. 309 p.

Extensive data is presented on ground water levels throughout the Northeastern United States. The report is broken into small areas (cities, counties, etc.) and into yearly analysis to give accurate analyses of level fluctuation. Very little discussion accompanies the data.

406. U. S. Geological Survey. 1958. Compilation of records of surface waters of the U. S. through September, 1950. Geological Survey Water Supply Paper 1307. 397 p.

The data presented comprise a description of gauging stations in St. Lawrence and Lake Ontario tributaries, tables of monthly and yearly discharge and runoff. The station location is presented, the tributary drainage area, mean and extremes of discharge.

407. U. S. Geological Survey. 196?a. Surface water records of New York 1962. U. S. Geological Survey, Water Resources Division, Albany, N. Y. 355 p.

The surface water records for the 1962 water year for gauging stations, partial-record stations and miscellaneous sites within the State of New York are given in this report. Tabulated data on daily water discharge in cfs for streams tributary to Lake Ontario and St. Lawrence River including the Niagara, Genesee, Black and Oswego Rivers. Descriptive statements are included for each sampling station. Included in these statements are sampling location, area (in sq. miles) of drainage, records available, average discharge, extremes and remarks.

408. U. S. Geological Survey. 196?b. Surface water records of New York 1963. U. S. Geological Survey, Water Resources Division, Albany, N. Y. 369 p.

The surface water records for the 1963 water year for gauging stations, partial-record stations and miscellaneous sites within the State of New York are given in this report. Tabulated data on daily water discharge in cfs for streams tributary to Lake Ontario and St. Lawrence River including the Niagara, Genesee, Black and Oswego Rivers. Descriptive statements are included for each sampling station. Included in these statements are sampling location, area (in sq. miles) of drainage, records available, average discharge, extremes and remarks.

409. U. S. Geological Survey. 196?c. Surface water records of New York 1964. U. S. Geological Survey, Water Resources Division, Albany, N. Y. 362 p.

The surface water records for the 1964 water year for gauging stations, partial-record stations and miscellaneous sites within the State of New York are given in this report. Tabulated data on daily water discharge in cfs for streams tributary to Lake Ontario and St. Lawrence River including the Niagara, Genesee, Black and Oswego Rivers. Descriptive statements are included for each sampling station. Included in these statements are sampling location, area (in sq. miles) of drainage, records available, average discharge, extremes and remarks.

410. U. S. Geological Survey. 1961. Surface water supply of the United States. Part 4 - St. Lawrence River basin, 1960. Geological Survey Water Supply Paper 1707. 437 p.

Extensive data is presented on the surface water supply in the St. Lawrence River basin. The report is broken into small areas (cities, counties, etc.) and into yearly analysis to give accurate analyses of level fluctuation. Very little discussion accompanies the data.

411. U. S. Geological Survey. 1964a. Compilation of records of surface waters of the U. S., October 1950 to September 1960. Part 4 - St. Lawrence River basin. U. S. Geological Survey Water Supply Paper 1727. 379 p.

Runoff and discharge parameters for all major rivers running into and out of Lake Ontario, including the Niagara River inflow and the St. Lawrence outflow. The location and drainage area of each river is also listed. (Canada Centre for Inland Waters).

412. U. S. Geological Survey. 1964b. Ohio River basin and St. Lawrence River basin. Water Supply Paper No. 1955. 440 p.

Tabulated surface water data include:

Temperature
Water color
Stream discharge
Sediment composition
Station equipment and location

The samples were taken at gauging stations throughout the lake and various tributaries.

413. U. S. Geological Survey. 1965a. Ground water levels in the United States - 1958-62. Geological Survey Water Supply Paper 1782. U. S. Government Printing Office, Washington, D. C. 252 p.

Extensive data is presented on ground water levels throughout the Northeastern States. The report is broken into small areas (cities, counties, etc.) and into yearly analysis to give accurate analyses of level fluctuations. Very little discussion accompanies the data.

414. U. S. Geological Survey. 1965b. Magnitude and frequency of floods in the U. S. - Part 4. The St. Lawrence River Basin. U. S. Geological Survey, Water Supply Paper 1677. 357 p.

Data is presented on discharge runoff, and related flood levels for all major rivers running into Lake Ontario and the St. Lawrence River. Data is also presented on river location and drainage area. (Canada Centre for Inland Waters).

415. U. S. Geological Survey. 1968. Water resources investigations in New York. Water Resources Commission, Albany, N. Y. Unnumbered.

Tables, maps and a bibliography of various essential components to a general understanding of the quality, quantity and composition of the water resources of New York State. Included are information on drainage, temperature, discharge and geology of New York State pertaining to water quality, quantity and composition.

416. U. S. Geological Survey. 1969. Quality of surface waters of the United States - 1964. Geological Survey Water Supply Paper 1955. U. S. Government Printing Office, Washington, D. C. Parts 3 and 4. 440 p.

The article encompasses many physical and chemical parameters pertaining to pollution levels and water quality in the St. Lawrence Basin. The major physical parameters are: mineral constituents of water, specific conductance, color, temperature, turbidity and sediment.

417. Upchurch, S. B. 1970a. Great Lakes basin - Limnology of lakes and embayments. Great Lakes Basin Commission, Ann Arbor, Michigan. 37 p.

Parameters included are: location, geology, dimensions, climate, winds and storms, temperatures, precipitation, runoff and groundwater. The interrelationship of many of these parameters are discussed in reference to climate and physical characteristics of the Lake.

418. Upchurch, S. B. 1970b. Lake basin physiography - Limnology of lakes and embayments, Great Lakes Basin Commission, Ann Arbor, Michigan. 23 p.

The paper includes in depth discussion on the drainage characteristics of the Lake Ontario and the tributaries leading to the Lake. The discussion includes several important drainage parameters. These parameters include:

Drainage volume and areas
Runoff
Lake level
Dimensions
Locations

419. Upham, W. 1896. Origin and age of the Lawrentian Lakes and of Niagara Falls. American Geologist. 28: 169-177.

The article discusses the preglacial condition of the St. Lawrence basin, changes bringing on the ice age, recessions of the ice sheet, glacial lakes in the St. Lawrence basin (Warren, Algonquin and Iroquois), the beginning of the Niagara River and its erosion of the gorge below the falls, flow variation in the Niagara River, duration of Niagara Falls of the postglacial period.

420. Upham, W. 1898. Niagara Gorge and St. David's Channel. Bulletin of Geological Society of America. 9: 101-110.

The report contains information on:

1. The Niagara Gorge - physical features.
2. St. David's Channel - preglacial extent, effects on the recession of the falls and location.
3. The effect of the Lawrential Lakes on the Niagara Gorge erosion.
4. Epeirogenic uplifting continued to the present time.
5. Epeirogenic uplifting contemporaneous with the glacial lakes.
6. Duration of Niagara Falls and the postglacial period.

421. Vanderpast. J. M. and B. J. Dutka. 1970. A bacteriological study of sediments in the Kingston basin and Lake Ontario outlet of the St. Lawrence River. Manuscript Report No. KR. 70-3 Division of Public health Engineering, Department of National Health and Welfare, Ottawa. 110 p.

During July, 1970, a detailed sediment sampling program was undertaken in the Kingston Basin and the St. Lawrence River outlet of Lake Ontario, by the Limnogeology Section of the Canada Centre for Inland Waters. Since there was no record of any bacteriological studies of the sediments in this area, a program of sediment analysis, designed to present detailed bacteriological information about the outflow environment of Lake Ontario was initiated. Specifically, the area lies between 44°04'N and 44°16'N and 76°20'W and 76°47'W. From this study, it was anticipated that distribution patterns of bacterial densities and bacterial biotypes for the study area would be obtained. An investigation into the effect, if any, of local conditions, ie. sewage treatment plant discharge industrial wastes, streams, on bacterial densities and biotype distribution, was also planned.

From the CCIW Vessel Lemoyne, sediment samples were collected by means of a Shipek grab sampler. From these Shipek samples, cores were removed by means of sterile plastic cylinder and the 0-2 and 4-6 cm sediment layers were tested for the following bacteriological parameters: coliform MF, 20°C MF plate count; 20°C MF anaerobic plate count; sulfate-reducing bacteria MPN; and autotrophic ammonium-oxidizing bacteria MF.

Twenty-two gram portions of sediment were belnded with 198 ml of phosphate buffer, at low speeds for one minute. From this blended sample, aliquoits were immediately tested for the various parameters.

Coliforms were found only in a few samples, in three widely dispersed areas. The highest coliform density recorded was 1200 coliforms per gm dry wt.

Aerobic bacterial densities were lowest in shallow rocky or sandy areas and increased as the sediments graded to black silt in the deeper basins. In the majority of samples the highest aerobic bacterial densities were found in the 0-2 cm layer with densities ranging from 80,000 per gm dry wt. in gravel or glaciolacustrine clay to 57,000,000 per gm dry wt, in black silty muds.

Anaerobic plate count densities were much lower than aerobic plate count densities. In two-thirds of the samples, higher anaerobic densities were found in the 0-2 cm layer than in the 4-6 layer.

Sulfate-reducing bacterial densities correlated very closely with anaerobic plate count densities, with the highest densities also occurring in the 0-2 cm sediment layer. A definite correlation between high sulfate-reducing bacterial densities, water depth and sediment type, i.e. black silty muds, was observed. Nitrifying bacteria were only found sporadically and their isolation appeared to correlate with industrial sites, farming areas and population densities.

422. Verber, J. L. 1966. Inertial currents in the Great Lakes. Great Lakes-Illinois River basin project, FWPCA. Proceedings Great Lakes Research Division, Univ. of Michigan. Publication 15, pp. 375-379.

The Great Lakes Illinois River Basins Project has completed field studies on currents on Lakes Michigan, Erie and Ontario. One of the dominant effects appears to be that the earths rotation produces right hand acceleration to the currents. The effects of the earths rotation on water movements in the Great Lakes has been portrayed in a film. Five patterns of flow are displayed: straight line flow, sinusoidal or oscillatory, half moon, circular or spiral and rotary or screw. Inertial flow is found in the Great Lakes at all depths and in all seasons, as well as under ice cover. With few exceptions, such as in the Straits of Mackinac and shallow inshore stations, some type of inertial flow is evident in the lakes.

423. Watt, A. K. 1951. Ground water in Ontario - 1947. Ontario Department of Mines. 60(11): 1-116.

Report contains extensive geological information, as well as topographic information of the Province of Ontario. A great deal of data are presented in Lake Ontario elevation, water levels and effects of runoff on water quantity and quality. (Univ. of Toronto, Great Lakes Institute).

424. Watt, A. K. 1961. Ground water in Ontario - 1953-54. Ontario Water Resources Commission, ground-water. Bulletin No. 1. 320 p.

This report contains data on Ontario ground water along with the geography, geology, drainage and climate of the province. Data are presented on Lake Ontario elevation, water levels, runoff, water quality and quantity. (GLI).

425. Watt, A. K. 1963. Ground water in Ontario - 1955-56. Ontario Water Resources Commission, Ground Water. Bulletin No. 2. 377 p.

This report contains data on Ontario ground water along with the geography, geology, drainage and climate of the province. Data are presented on Lake Ontario elevation, water levels, runoff, water quantity and quality. (Univ. of Toronto, Great Lakes Institute).

426. Watt, A. K. 1965. Ground water in Ontario - 1957. Ontario Water Resources Commission, Ground Water. Bulletin No. 3. 208 p.

This report contains data on Ontario ground water along with the geography, geology, drainage and climate of the province. Data are presented on Lake Ontario elevation, water levels, runoff, water quality and quantity. (Univ. of Toronto, Great Lakes Institute).

427. Watt, A. K. 1966. Ground water in Ontario - 1958. Ontario Water Resources Commission, Ground Water. Bulletin No. 4. 257 p.

This report contains data on Ontario ground water along with the geography, geology, drainage and climate of the province. Data are presented on Lake Ontario elevation, water levels, runoff, water quantity and quality. (Univ. of Toronto, Great Lakes Institute).

428. Webb, M. S. 1970. Monthly mean surface temperatures for Lake Ontario as determined by aerial survey. Water Resources Research. 6(3): Unnumbered.

For calculations of evaporation losses by mass transfer techniques, and for many other research and operational applications, it is necessary to know the mean patterns of surface water temperature. The work of Millar (1952) has been widely used whenever such information is required for the Great Lakes. This paper presents preliminary patterns of monthly mean surface water temperatures for Lake Ontario based on 36 airborne radiation thermometer surveys over a three-year period. Temperature values at each of the 89 points in a grid have been plotted against calendar date, and an annual temperature curve has been produced for each point. Values for the middle of each month have been determined by interpolation, and used to produce a pattern for each month. The patterns are briefly compared with Millar's. Over the next few years as the airborne radiation thermometer (ART) surveys continue to add to the data band, it is planned to update these analyses. Therefore, these monthly values must be considered tentative at this time. (Canada Centre for Inland Waters).

429. Weiler, H. S. 1968. Current measurements in Lake Ontario in 1967. Proceedings 11th Conference Great Lakes Research. pp. 500-511.

During the summer of 1967, two sets of moorings with current meters were placed in Lake Ontario, by the Canada Centre for Inland Waters. Data sampling was every 10 minutes, and the data from temperature, water speed and direction sensors was recorded in 1/4 inch magnetic tape. Initial analysis has begun, and preliminary results show that during summer stratification, there are edge waves traveling counter-clockwise along the northern shore near Toronto, which have a phase speed of less than half that determined from theoretical consideration. The difference for the 17 hour periodicity is not considered significant, since the actual configuration of the bottom or stratification does not conform to the theoretical models.

430. Weiler, H. S. and C. R. Murthy. 1971. The Niagara River plume, Part 1., temperature and current structure in the Niagara River plume; Part 2, the mixing of the Niagara River plume in Lake Ontario. Inland Waters Branch, Technical Bulletin No. 38, Canada Centre for Inland Waters. Unnumbered.

A descriptive study off the mouth of the Niagara River was carried out in 1968 to obtain information on the dynamic behaviour of the river's plume, both in terms of gross movement, as well as diffusive properties.

Part 1 of the report encompasses the results of temperature surveys, drogue tracking experiments and infrared line scanner mosaics. These results show that the river's plume is strongly influenced by the dominant winds of the day before the experiment, and to a lesser extent those of the preceding day. Response time of the plume to persistent changes in wind was estimated to be between 1 and 2 days. Surface currents in the lake, driven by over-lake winds, controlled the motion of the plume; the motion was quite varied and complex, depending on the wind fields encountered, a fact that showed up most clearly on the infrared line scanner mosaics.

Part II of the report encompasses the diffusion studies carried out in the same area. The mixing of the river's plume with the main body of the lakes was found to take place in two stages. Fairly close to the river's mouth, very strong river-type mixing was found. Beyond this area, buoyant surface spread of the warmer river water over the colder lake water occurred. These findings are consistent with the results of Part I. (Canada Centre for Inland Waters).

431. Weist, W. G. and G. L. Giese. Water resources of the central New York region. U. S. Geological Survey, Albany, N.Y. Bulletin No. 64. 58 p.

This report summarized the available data on the water resources of the Central New York Region which includes Cayuga, Cortland, Madison, Onondaga and Oswego Counties--an area of 3,622 square miles centering around Syracuse. The 740,000 people living in the region use about 310 mgd (million gallons per day) of water for domestic and industrial purposes. About 90% of this water presently comes from surface-water sources.

The region includes parts of four major drainage basins: the Mohawk River, the Oswego River, the Susquehanna River and the Lake Ontario plains. Streamflow in the region is highly variable both from time to time, and from place to place. Generally, flow is greatest during March through May and lowest during July through September. During periods of low flow, most of the water comes from ground-water discharge. Streams such as Chittenango Creek, that have large areas of storage in lakes, swamps, or extensive permeable deposits along them, have larger more dependable low flows than do streams that lack such storage areas. These streams may even go dry during periods of deficient rainfall. The only stream with a minimum average 7-day, 2-year flow greater than 50 cfs (cubic feet persecond) are the Salmon River below Salmon River Reservoir and the Seneca, Oneida and Oswego Rivers. Over half of the streams in the region have a minimum average 7-day, 2-year flow less than 2 cfs. In general, the quality of the surface water tends to be better than than of most of the flow which comes from the ground water.

Ground water in the region occurs in both consolidated deposits (bedrock) and unconsolidated deposits (sand, gravel, etc.). The bedrock can be divided into seven units on the basis of similarity of lithology and hydrologic properties. These units are, in ascending order from north to south: lower shale, sandstone, sandstone-shale, dolomite, middle shale, limestone and upper shale. In all of these units, ground water occurs chiefly along bedding planes and joints. In the more soluble units, such as the limestone and middle shale, these openings have been enlarged by solution. The middle shale unit contains considerable amounts of gypsum and salt, which are soluble in water; thus its water is almost invariably of very poor quality. Water from the limestone is likely to be very hard, but usable whereas water from the remaining bedrock units is generally of better quality.

The best source of ground water in the region are the unconsolidated deposits of sand and gravel in the major valleys. The amount of water available from these deposits commonly can be increased through induced recharge or artificial recharge. A total of more than 240 mgd can be developed from the better sand and gravel aquifers. Water from the unconsolidated deposits generally reflects the quality of the water of the underlying bedrock.

432. Whittlesey, C. 1867. On the ice movement of the glacial era in the valley of the St. Lawrence. Proceedings American Association Advancement of Science, 15th Meeting. pp. 43-54.

Extensive analysis of glacial deposits, their location, occurrence, properties and structures is used to analyze the extent, numbers and movements of the various ice sheets in the St. Lawrence Valley.

433. Wiggin, B. L. 1950. Great snows of the Great Lakes. Weatherwise. 3(6): 123-126.

Citing the great snow storms which have occurred in the area in the past, several conclusions about lake effect storms are reached. They are prevalent when: 1) cold polar air moves across the lake, 2) there is a cyclonic curvature to the flow pattern, 3) there is a definite air water temperature difference, 4) there is a long fetch over the water and 5) there is a shear to produce longilu convective cells.

The worst storm occurring was in January of 1940 with 8' of snow and 20' drifts occurring.

434. Williams, E. T. 1916. Niagara-queen of wonders. Chapple Publishing Company, Ltd., Boston. 188 p.

A graphic history of the big events in three centuries along the Niagara Frontier, one of the most famous regions in the world, including early explorations, early literature, early wars, electrical power development, area conservation of natural resources and creation and development of the City of Niagara Falls. (Schoellkopf Museum, Niagara Falls, N. Y.).

Williams, G. W. - See: P. E. Greeson, No. 19[illegible]

435. Wilshaw, R. and D. R. Rondy. 1965. Great Lakes ice cover, winter 1964-65. Lake Survey, Corps of Engineers, Detroit, Michigan. Report 5-[illegible], 38 p.

In January of 1963, the U. S. Lake Survey initiated a program to acquire data related to the formation, distribution, movement and decay of ice in the Great Lakes. Data were collected at predetermined time intervals at selected locations by utilizing aerial photography and visual observations. This report covers the procedures and methods used for collecting ice cover data on the Great Lakes for the winter of 1964-65. (Canada Centre for Inland Waters).

Woodrow, D. L. - See: R. G. Sutton, No. 373.

436. Woodrow, D. L., R. G. Sutton and N. A. Rukavina. 1967. A drowned beach in Lake Ontario, west of Rochester, New York. Proceedings 10th Conference Great Lakes Research. pp. 157-161.

Fathometer traces, cores and grab samples were utilized to determine the configuration of the bottom and the distribution of the bottom sediments in nearshore Lake Ontario between Rochester and Braddock Point New York. The data indicate a smooth, sandy bottom extending from the present shoreline to water depth of 25 feet. A rough, steep sloping bottom with boulder accumulations exists between water depths 25 and 50 feet. At water depths greater than 50 feet, the bottom is smooth and silty. The boulder size zone is parallel to the modern shoreline and is approximately 1/2 mile offshore. The writers interpret the boulder zone as a drowned beach.

The bays and swamp landward of the drowned beach have been covered by modern lake sediments.

437. Wright, G. F. 1898. The age of Niagara Falls as indicated by the erosion at the mouth of the gorge. Abstract of paper presented American Association Advancement of Science, 47th Meeting. pp. 299-300.

A conservative estimate of the rate of disintegration for the 70 ft. of Niagara shales supporting the Niagara limestone would be 1/4 of an inch per year, with a probable rate of 1/2 inch per year. But at the lowest estimate no more than 10,000 years would be required for the enlargement of the upper part of the mouth of the gorge 388 feet on each side, which is very largely in excess of the actual amount of enlargement. The age of the gorge cannot be much more than 10,000 years and is probably considerably less.

Yu, S. L. - See: W. Brutsaert, No. 46.

438. Yu, S. L. and W. Brutsaert. 1968. Estimation of near surface water temperatures of Lake Ontario. Proceedings 11th Conference on Great Lakes Research. pp. 512-523.

The relationship was analyzed between Lake Ontario surface water temperature and air temperature and sunshone percentage data observed at four peripheral stations. Time series and regression analysis were performed and different estimation equations were compared. It was found that there was practically no correlation between water temperature and sunshine anomalies, and that water temperature could be estimated with an average coefficient of determination of 0.44 by using the present and the past two to four months of air temperature data.

439. Zenger, D. H. 1965. Stratigraphy of the Lockport formation (Middle Silurian) in New York State. NYS Museum and Science Service, Albany, N. Y. 210 p.

The origin, composition, erosion and location of the Lockport formation in Western New York State. Atricle includes properties and structures, material erosion and general features. (Schoellkopf Museum, Niagara Falls, N. Y.).

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VI. ACKNOWLEDGEMENTS

We would like to thank the librarians and scientists without whose assistance this compilation would not have been possible. We are particularly appreciative of the cooperation by Donna Browning, Elizabeth Robins and Ruth A. Sparrow of the Buffalo Museum of Science; Emma Fosdick of the Canada Centre for Inland Waters; Rhea Bush of the Erie County Public Library; Ruth Rehfus of the Great Lakes Laboratory of the Bureau of Sports Fisheries and Wildlife (Ann Arbor); Albert Ballert of the Great Lakes Commission; Jean Seddon of the University of Toronto; Delloss Matheson of the City of Hamilton; Arthur Pinsak of the U. S. Lake survey and Andrew Robertson of NOAA.

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